UNIVERSITY OF GLOUCESTERSHIRE

at Cheltenham and Gloucester

Doctor of Philosophy (PhD)

at the

University of Gloucestershire

Florian Lotte

A consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance

First supervisor: Prof. Dr. Brian Terry

Second supervisor: Mr. Jeremy Wallwork

A thesis submitted to the University of Gloucestershire in accordance with the requirements of the degree Doctor of Philosophy (PhD) in the Faculty of Business, Education and Professional Studies

Submission: 24.07.2017

Author's declaration

I declare that the work in this thesis was carried out in accordance with the regulations of The University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas. Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed ______________________________ Date _______24.07.2017______

Acknowledgements

I would like to take the opportunity to thank all the people who have directly and indirectly supported me during the course of this doctorate.

In this context I would like to name my business supervisors at work as well as all experts from the different business areas who have participated in this research in order to make a valuable contribution both to knowledge as well as business practice. The interviews, process observations, access to data as well as numerous conversations and discussions throughout the entire doctoral journey were invaluable for the outcome of this thesis.

Furthermore, I would like to thank my doctoral supervisors, Prof. Dr. Brian Terry and Mr. Jeremy Wallwork for their constant support, guidance and input throughout the last years. Their expertise and motivation helped me produce a thesis on doctoral level.

I would also like to thank all proof readers for their help and input in finalizing this thesis.

Most of all, I would like to thank my family and friends for their understanding as well as continuous motivation and support throughout the last years. All of them stood back in order for me to be able to reach my goal of successfully finishing this doctorate.

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List of abbreviations and acronyms

ALS	Action Learning Set
ATM	Automatic Teller Machine
AUD	Australian Dollars
BA	Business Area
BO	Back Office Support
BOM	Bill of Material
BSC	Balanced Score Card
B2B	Business-to-Business
B2C	Business-to-Customer
CHF	Swiss Francs
CO	Competitive Objective
DAU	Driving to/Accessing the Unit
E	Elevator Business Area
EBIT	Earnings before Interest and Taxes
ERP	Enterprise Resource Planning
FAM	Functional Analysis for Maintenance
GPS	Global Positioning System
ISLA e.V.	International Service Logistics Association eingetragener Verein (registered society)
I	IT Hardware Business Area
IF	(Perceived) Influence Factor
IP	(Perceived) Improvement Potential
IT	Information Technology
Jr.	Junior
KPI	Key Performance Indicator
M	Mining Equipment Business Area

METRIC	Multi-Echelon Technique for Recoverable Item Control
MLDT	Mean Logistics Delay Time
MRL	Machine-Room-Less
MRO	Maintenance, Repair and Overhaul
MTBF	Mean Time between Failures
MTTR	Mean Time to Repair
n.d.	No Date
NIC	Non-Influenceable Circumstance/Other Factor
ODI	Operative/Direct Influence
OEE	Overall Equipment Efficiency
OEM	Original Equipment Manufacturer
ORD	Ordering
OSD	On-Site Diagnosis
PC	Personal Computer
PDA	Personal Digital Assistant
PhD	Doctor of Philosophy
PMS	Performance Measurement System
PSS	Product-Service System
PUDO	Pick-Up/Drop-Off Point
Q&A	Questions and Answers
R&D	Research and Development
REC	Receiving
RED	Remote Diagnosis
REP	Repairing
RFID	Radio Frequency Identification
RMB	Chinese Renminbi

RO	Research Objective
RQ	Research Question
SCM	Supply Chain Management
STI	Strategic Influence
TA	Technical Assistance
TE	Technician Enabling
TPM	Total Productive Maintenance
TQM	Total Quality Management
USD	United States Dollars

Abstract

Purpose/objectives: This research deals with the development of a consensus construction to understand and to optimize factors affecting service technicians response time in corrective maintenance processes for stationary equipment, i.e. equipment that can generally not be relocated for maintenance and repair, in different business areas, i.e. elevator, mining equipment and IT hardware. In this context, the goal of this research is to identify competitive objectives with respect to corrective maintenance, factors that are perceived to influence service technicians in this process as well as perceived improvement opportunities. Based on this, a consensus construction to be utilized in the researched community has been developed in order to optimize the according response times. The construct may also be used as a baseline for further research in this context.

Design/methodology/approach: The empirical part of the research conducted has been targeted with an abductive, qualitative, multiple case study approach. The need for this research has been identified through an in-depth and iterative literature review and the methodology chosen, i.e. multiple case study research, has been justified. The empirical part to contribute to closing the research gap has thereby been divided into four parts:

1. Preparation of research and pilot
2. Case studies and result documentation
3. Analysis, interpretation and consensus construction development
4. Conclusions, limitations, outlook and recommendations

Findings: The findings represent a significant contribution both for knowledge as well as business practice. In addition to the identification of further gaps in research, the literature review thereby isolated a specific need with regards to understanding and improving factors affecting service technicians in stationary equipment corrective maintenance response time. In this context, numerous concepts, such as PSS, servitization, competitive objectives/priorities, corrective maintenance, response time reduction, etc. have been reviewed, put into context, displayed in a structured way and contributed to by this research. Furthermore, a set of 57 perceived factors influencing the corrective maintenance process and 87 perceived improvement opportunities has been identified. The consensus construction structures and prioritizes these, gives action recommendations and makes the findings available for application in business practice in the community studied. Last but not least, the research conducted has risen the awareness for the importance of this topic.

Limitations: The research focuses on establishing a consensus construction with regards to corrective maintenance response time optimization for stationary equipment limited to the participants/community of this study, i.e. elevator, mining equipment and IT hardware. Other identified gaps in literature, as well as a focus on other business areas, preventive maintenance, B2C industries, and non-stationary equipment have not been dealt with in detail in this context and need to be looked at in further research.

Recommendations for further research: The consensus construction has not yet been implemented in business practice. The implementation will have to be part of further studies and research. Additional research may also include aims to generalize the results beyond the current limitations and community studied, and additional adjustments to the construction might be considered, e.g. a combination with other available frameworks, as well as testing the applicability to non-stationary equipment or in B2C markets.

1 Introduction

1.1 After-sales service in market oriented business environments

A rising trend has shown more and more importance in the past years throughout all major industries. Customer satisfaction is a key strategic goal to any organization, as stated by numerous authors (e.g. Christopher, 2010; Dölarslan, 2014; Politis, Giovanis and Binioris, 2014; Ali, Leifu, Rafiq and Hassan, 2015). The processes to support customers and their needs by developing, manufacturing and delivering as well as servicing products have become inevitable for the companies (Christopher, 2010). Whilst in the past, people and companies lived and operated in a fairly production oriented market especially after World War II, where demand was higher than availability and thus nearly everything that was produced could be sold, a major focus on customer needs was not needed (Schulte, 2001). Manufacturing companies therefore only had to focus on production capacities and efficiency in order to compete in the market while automatically achieving customer satisfaction (Guo, Wang and Metcalf, 2014).

This has changed. Today's businesses now have to focus more and more on a customer and market oriented approach (Christopher, 2010; Guo and Wang, 2015). Whether it is a car or a supermarket in the business-to-consumer (B2C) market, or it is a machine or any other capital investment good in the business-to-business (B2B) market, the choices for the customer usually vary between different forms of suppliers, e.g. direct sellers or wholesalers, etc., and even possibilities to order and buy, e.g. in stores or online, etc. Additionally, the amount of different suppliers for each of the available products and services gives the customer the bargaining power (Hayes and Dredge, 1998; Günthner, 2008). On the one hand, with usually very little effort and low emotional connection to a specific company, the customers can switch to the competition, if they do not feel treated in the expected way or did not get the value they expected out of their purchase. On the other hand, if people believe to be getting the value and service for what they paid, the relationship and emotional attachment to the company may be strengthened and result in further business between the parties (Hayes et al, 1998; Christopher, 2010; Ali et al, 2015).

By adapting to a market oriented approach, the focus for manufacturers therefore shifts towards creating superior value for customers through the identification and satisfaction of explicit customer needs and demands (Narver and Slater, 1990; Christopher, 2010; Guo et al, 2014, Guo et al, 2015).

This shift in approaches is underlined by statements of two successful people of their particular era: In the early 20th century Henry Ford's famous words "Any customer can have a car painted any colour that he wants as long as it is black" (Ford, 2007, p. 72) and thus dictating the options for the customer did not hinder him from positioning and building a very successful automobile company in the market. In today's globalized business world with the large amounts of products and services available, however, this would be somewhat impossible to achieve. Sam Walton (as cited in Wellington, 2010), founder of Wal-Mart supermarkets, stated the role of the customer in today's business environment with the words "There is only one boss. The customer. And he or she can fire everybody in the company from the chairman down, simply by spending their money somewhere else" (Wellington, 2010, p. 1).

It is essential for companies to realize the changed business environment and to know how to deal with it in order to be successful (Christopher, 2010). As products and services in most major industries today, regardless of B2C or B2B, are very similar or have many substitutes, in order to stand out of the mass and to be successful in creating customer satisfaction, it is essential for companies in the current business environment to distinguish themselves from their competitors (Christopher, 2010; Wellington, 2010). Porter (1985) was one of the first to build a model to accommodate this task. He realized that a "competitive advantage grows fundamentally out of value a firm is able to create for its buyers that exceeds the firm's cost of creating it" (Porter, 1985, p. 3). In his model, Porter (1985) describes that this competitive advantage and thus customer satisfaction can either be generated by cost leadership for a product/service or by creating additional values for the customer through differentiation. The optimum to aim for is to become cost and value leader through differentiation at the same time. Please refer to **Figure 1,** which displays this concept (Christopher, 2010).

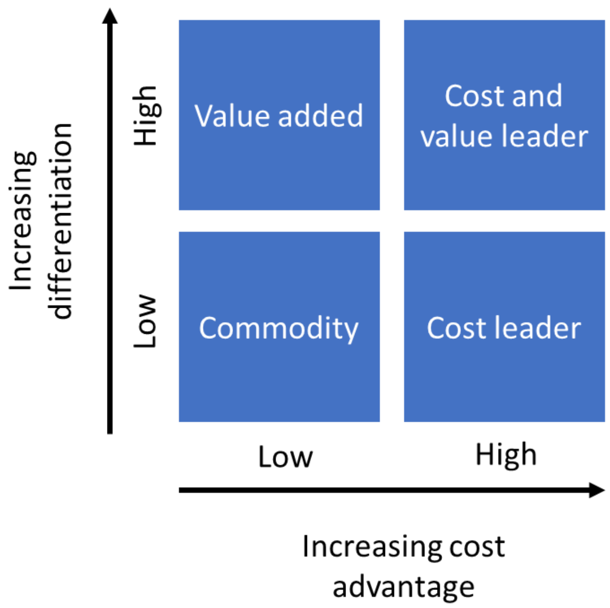


Figure 1: The competitive options (Own figure based on Christopher, 2010)

In order to become market and customer oriented, create a competitive advantage and customer satisfaction, a rising trend in literature suggests for companies to go through a process of servitization, according to Gáspár and Szász (2014). Servitization as a term was first introduced by Vandermerwe and Rada in 1988, who explain the importance and focus need for manufacturing companies to add value to their products through services. Wise and Baumgartner (1999) reemphasized this by explaining the need for manufacturing companies to go downstream, i.e. move closer to the customers, which means to satisfy them by providing offerings around the core product, which again creates more value for the customer and thus higher satisfaction, and eventually profits for the manufacturer.

Until today, the literature concerning servitization has increased far beyond these two papers. While in the past, services were usually seen as an add-on by goods manufacturers, nowadays and through the need to become market oriented, they are getting recognized as a booster for differentiation and thus additional margins more and more (Oliva and Kahlenberg, 2003; Strähle, Füllemann and Bendig, 2012; Garikaparthi, 2014). This is supported by Oliva, Gebauer and Brann (2012), who state that especially companies in the B2B market with high-value machinery and equipment as well as long lifecycles heavily rely on service revenues, as these oftentimes make up for approximately 50% of the overall revenues and profits.

According to Oliva et al (2003), besides the potential to generate high as well as stable revenues and margins through services that compliment products and units, especially when these have a long lifecycles, services are in high demand by customers as they themselves have financial pressure and need high-value equipment to run longer than in the past. Furthermore, according to the authors, services are harder to copy and can therefore create a much more sustainable competitive advantage for the manufacturing companies.

Baines, Ziaee Bigdeli, Bustinza, Guang Shi, Baldwin and Ridgway (2017) in their most recent literature review state that more than 230 articles focussing specifically on servitization have already been published in peer-reviewed journals, with communities such as service management, service science and service marketing, operations management as well as product-service systems (PSS), etc. all contributing to this topic. Raddats and Kowalkowski (2014) as well as Candi and Kahn (2016) add that the amount of literature generated in this area shows that manufacturing companies and especially those in B2B markets are aiming to create or maintain their competitive advantage against other providers with similar goods/services through servitization.

Not every company that decides to servitize and thus moves towards more market orientation does this in the same way, however. According to Raddats et al (2014), servitizing manufacturers can have different service strategies and thus different levels of service added to their products. For instance, the authors state, that some companies may focus on enhancing the reliability of their products sold through additional after-sales services such as offering spare parts or repair services and technical support. Other companies may decide to increase their revenues by entirely or partly outsourcing services, and even other manufacturers may decide to provide product-service solutions, with the main products remaining in the manufacturers' ownership and only being leased to the customers or given to them with charging mechanisms based on the performance output of the equipment.

These different service strategies of manufacturers can be clustered into different PSS. As stated by Tischner, Verkuijl and Tukker (2002) as cited in Tukker (2004), PSS are "tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs" (Tukker, 2004, p. 246). Tukker (2004) adds that this basically means that different combinations of products and services can be used to generate added value and customer satisfaction and therefore increased competitiveness for the manufacturer.

Out of all services that potentially can be added onto products, after-sales services, such as spare parts provision, repair and maintenance, training and technical support, etc. (Gebauer, Ren, Valtakoski and Reynoso, 2012), according to numerous authors (e.g. Oliva et al, 2003; Cavalieri, Gaiardelli and Ierace, 2007; Ahn and Sohn, 2009, Alvarez, Ramos Martins and Terra da Silva, 2015), play an especially important role in servitization. Besides the general advantages that services boost in this concept mentioned previously, according to Cavalieri et al (2007), Ahn et al (2009) as well as Alvarez et al (2015), servitized and servitizing firms through after-sales services can create a much closer proximity to the customer, which again helps to generate further business and improve the customer relationship and loyalty. Also it can result in mutual communication regarding new business opportunities.

Given the relevance of after-sales services in servitization (e.g. Oliva et al, 2003; Cavalieri et al, 2007; Ahn et al, 2009, Alvarez et al, 2015) and especially the rising relevance of servitization in the B2B market, as stated by Oliva et al (2012) and Raddats et al (2014), in order to create competitive advantages for manufacturing companies, this thesis will particularly focus on this area.

1.2 The role of after-sales services in different markets

1.2.1 Selection of business areas

Three B2B-business areas have been selected to be looked at in depth and in detail for this thesis. These will be introduced in this chapter and the relevance of after-sales services for them will be displayed. Namely, the business areas selected are elevator (E), mining equipment (M) and IT hardware (I).

These business areas have been selected for numerous reasons. As **Chapter 1.1** shows, a focus on after-sales services such as spare parts logistics, maintenance, etc. to generate competitive advantages for servitizing/servitized manufacturing companies in B2B markets has been identified to be increasingly relevant in today's market oriented business environment.

As after-sales services play a crucial role with regards to competitiveness in these business areas, as will be displayed in this chapter, they have been chosen to be looked at in more depth throughout this research.

Also, with this selection of business areas, it was intended to include different maturity levels of servitization as well as PSS approaches. While this can be specifically different from company to company in each of the business areas, the general status for the business areas showed that the topic of servitization has reached the highest relative maturity level in IT hardware, followed by elevator and then mining equipment. If generally a solely product-centric focus of an industry acts as a baseline, then the IT hardware business area therefore has furthest evolved in servitization, while the mining equipment industry comparably has developed the least and elevator ranking in between. Additionally it can be stated, however, that in all of these business areas selected, companies exist that operate in different PSS, i.e. varying degrees and combinations of products and services offered to the customer.

Furthermore, the literature review (**Chapter 2**), which aimed at identifying gaps in research in this area, has revealed that more research in the field of after-sales services of servitizing/servitized manufacturing companies is needed especially with regards to understanding and improving factors affecting service technicians' performance in terms of service response time in corrective maintenance for stationary equipment. It is therefore the goal of this thesis to generate a consensus construction around this research gap, which serves to contribute to the knowledge base as well as the applicability in the businesses studied in this research.

In order to accommodate to generate a construct that has been enriched through a multitude of different viewpoints and expertise, three business areas and adjacent companies, which differ in multiple aspects from one another, but also share similarities, have been chosen in order to provide a wide view and a diverse portfolio of different cases. The level of similarities, especially with regards to the processes and circumstances in stationary equipment corrective maintenance, etc. thereby allows for a comparison of the selected business areas, as suggested in the concept of theoretical sampling (Glaser and Strauss, 1967).

The literature review also revealed that speed/timeliness and thus response time was identified to be a major objective with regards to this topic. Therefore, one selection criteria for the business areas to be included in this research was the general or average need for quick response time in cases of equipment failure. A second selection criteria was the average or general cost for equipment in these business areas. The selected business areas could be clustered as displayed in **Figure 2**, showing differences in both of the named aspects. Business areas clustered in different areas of the display were specifically searched for to add onto the diverse use of resources for the consensus construct.

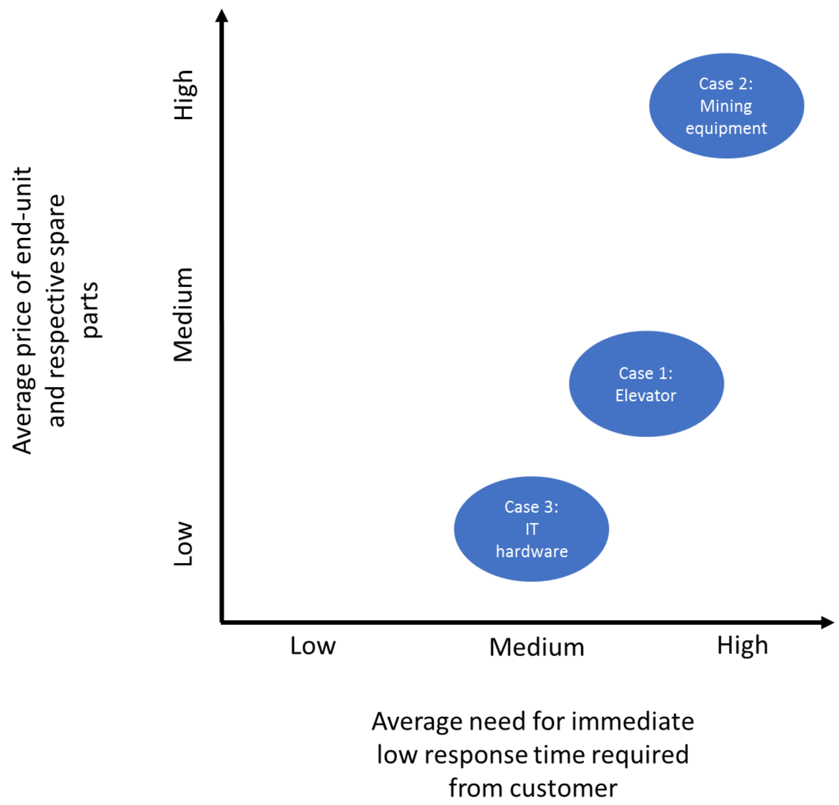


Figure 2: Business areas covered in this research

The first business area included for this research is the elevator business area. Here, companies generally produce/service capital goods priced in the multiple ten thousand Euros sector. A need for service responses from the customer generally varies and depends on frame contracts agreed on. However, in most cases, a medium to high need for quick responses are needed, especially in production settings or in hospitals, etc. The second business area observed is the mining equipment business area. The companies in this business area produce/service capital goods priced in the multiple million to billion Euros. Failure of equipment is extremely expensive and a high need for quick response times is therefore required. The third business area looked at is the IT hardware industry for (mainly) industrial goods such as printers, where the companies produce/service capital goods priced in the multiple ten to hundred/thousand Euros sector. Here, a medium need for quick response times is needed, depending on how many alternatives to a broken down unit are available and the frame contracts agreed upon.

The three business areas will be introduced in more depth and the relevance of after-sales service in these areas will be explained in the following chapters.

1.2.2 Elevator business area

The elevator business area, which usually also always includes escalators, is mainly made up of three different types of businesses. On the one hand, there are new installations of elevator and escalator units, on the other hand there are services such as modernizations of installed elevators and escalators as well as maintenance services on the installed units (Koncept Analytics, 2010). The general lifecycle of an elevator and escalator unit thereby can be described in four steps: Firstly, new equipment is installed in a building or a likewise location. Secondly, it will then undergo maintenance for most of the unit lifecycle, before thirdly and hopefully after a long period of operational time, main components of the units such as the gear, etc. will need to be exchanged and modernized in order to comply with new technical advancements, safety regulations, environmental factors, architectural needs, etc. At the end of the lifecycle, which is usually after 30-35 years, the unit will be fully replaced and the lifecycle starts from the beginning again (Koncept Analytics, 2010).

A multitude of different products exists in this business area and depending on the manufacturer. Focusing on elevators in general, first of all a separation can be made between hydraulic as well as electric elevator units. A further differentiation can then be made between gearless elevators, geared hydraulic elevators as well as machine-room-less (MRL) elevators (Koncept Analytics, 2010). Newly innovative concepts such as the ThyssenKrupp MULTI, which will be the world’s first rope-free elevator system (ThyssenKrupp, 2015), or product adaptations to meet local demands, such as the KONE E MiniSpace launched in 2012 to comply with the need for affordable and small elevators in the Chinese housing segment (Johnson, 2013), will continue to change the market and are a valuable tool for the manufacturers to strengthen their market positions.

In total, the elevator business area is currently expecting a potential market size of 115 billion USD (United States Dollars) by 2017, according to Statista (2015a). This equals an approximate 34% growth compared to 86 billion USD in total market size in 2012. Please refer to **Figure 3** for a graphical display of the development in the elevator business area between 2012 and the expectation for 2017.

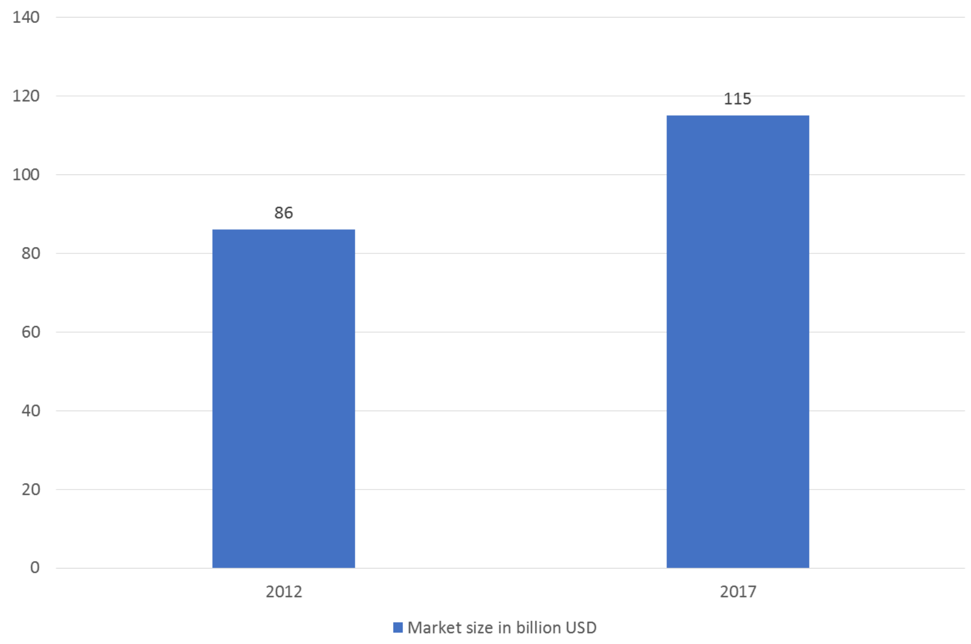


Figure 3: Market size growth in the elevator business area (Own figure based on Statista, 2015a)

Key manufacturers of elevator equipment in this business area are, for example, Otis, KONE, Schindler, ThyssenKrupp, Hitachi, Toshiba, Fujitec and Mitsubishi. In addition to these, there are large numbers of further smaller or local elevator companies (Tiwari, 2015). The five main competitors are Otis, Mitsubishi, Schindler, KONE and ThyssenKrupp, which have generated the majority of revenues in this business area in the past years. In 2014, Otis led the market with a revenue of 12.98 billion USD (Statista, 2015b). Please refer to **Figure 4** for an overview.

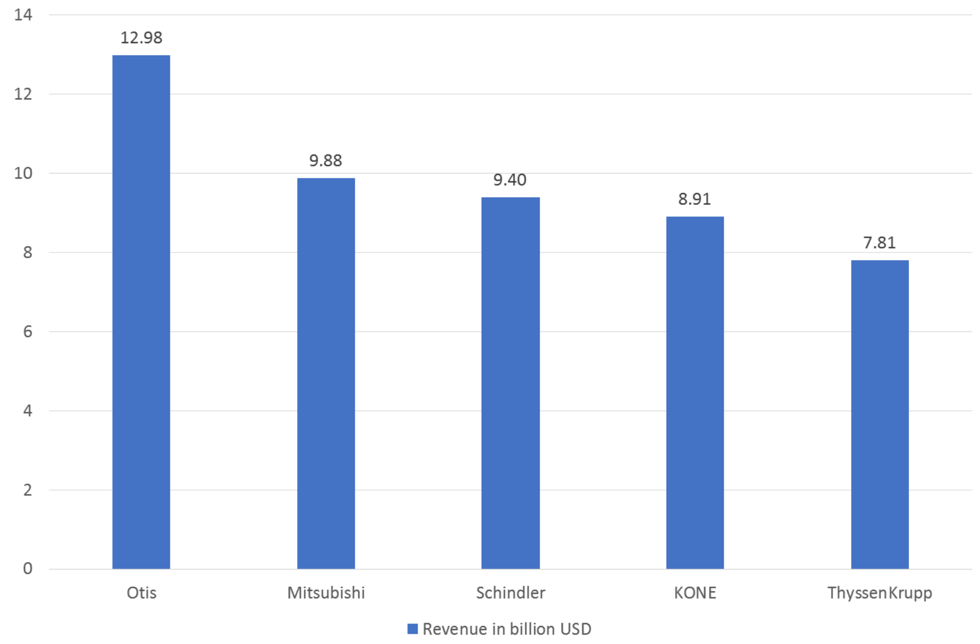


Figure 4: 2014 revenue in USD by major elevator company (Own figure based on Statista, 2015b)

With the exception of Mitsubishi, which is based in Asia, these key manufacturers are mainly based in Europe (KONE in Finland, Schindler in Switzerland and ThyssenKrupp in Germany) as well as North America (Otis in the United States). The most prosperous countries for new equipment and thus also boosting large possibilities in service and spare parts logistics as well as maintenance are the highly populated Asian areas, especially China and India (Statista, 2015b), however. China, according to The Economist (2013) as well as Hagmann, Gibson, Zimmermann and Chand (2015), accounted for two thirds of all new elevator installations worldwide in 2014. The developed countries in Europe and North America, according to The Economist (2013) as well as Statista (2015b) nonetheless, however, will also continue to be striving markets both for new installations due to the aging population in need of transportation modes, but especially in service and spare parts logistics in combination with maintenance due to the aging of the installed base that needs to be refurbished. This becomes especially clear when looking at the overall installed base in this area, which accounts for approximately half the world's total installed elevators currently (The Economist, 2013).

While demand for new installed equipment has risen to approximately 700,000 units in 2013 from roughly 300,000 about a decade ago, according to The Economist (2013), especially maintenance service margins are the key to success in this business area. Whilst about 10% margins can be expected from new installations, the margins in maintenance service level at around 25 to 35% (The Economist, 2013). Additionally, the margins from service are more stable in this business area as service is needed at all times on all units in order to prevent break-downs and people getting stuck. New installation margins contrary are more volatile depending on the general economy (The Economist, 2013). This was especially true in the financial crisis of 2009, where maintenance margins remained stable while new unit sales declined (Koncept Analytics, 2010). Elevator companies therefore split their business accordingly and focus roughly 60% of their activities on service versus 40% in new equipment (Koncept Analytics, 2010). Strähle et al (2012) support this statement by emphasizing that the benefits from this split of focusing on service rather than on new installations can be seen with the four main competitors in the European market (Otis, KONE, Schindler and ThyssenKrupp) increasing their EBIT (earnings before interest and taxes) by approximately 56% between 2008 and 2009, while other companies, which focused largely on new installation sales, in the same time period had average declines in earnings of roughly 37%. The same trend can be seen outside of Europe as well. In China for example, Shenyang Brilliant Elevator in 2013 has risen its revenue from maintenance service by 31.4% to 280 million RMB (Chinese Renminbi), which accounted for 16.9% of the total revenue. Three years before, this share was still at 9.1% (Tiwari, 2015).

1.2.3 Mining equipment business area

According to different authors, e.g. Ericsson (2012), The Mining Association of Canada (2014), etc. the mining industry is the backbone of human development. Mining products are natural resources, which include base metals such as iron, nickel, zinc, copper, etc. as well as precious metals such as gold and silver, among others. Other mining products are commodities such as coal, etc. These products are the key source for many other industries, especially in construction and machinery, but also in high-tech industries (Ericsson, 2012; Mousavizadeh, Haynes, Russel, Newall, van der Wath, Lavan, … and van Rhyn, 2013; Statista, 2015c).

Similarly to the elevator business area, in mining a multitude of different products that go through the same product lifecycle of new installation, maintenance service and modernization to full replacement, exist. The full product range thereby includes shovel and bucket-wheel excavators, trucks, crushing facilities as well as transport facilities, screening equipment, grinding facilities, flotation and separation as well as filtration facilities, storage equipment and finally loaders, such as for trains and ships (Shehata, 2014).

The mining market is made up by a large and diverse group of different companies. Amongst the top 40 operators of mines are companies from all continents, e.g. Barrick Gold Corporation from Canada, China Coal Energy Company from China, Fortescue Metals Group from Australia, Glencore Xstrata from the United Kingdom, Impala Platinum Holdings from South Africa and Vale from Brazil. Other major players worth mentioning in this context include Anglo American, BHP Billiton, Glencore as well as Rio Tinto (Gravelle, Winzenried and Hodge, 2014; Brunet, Devevey, Pez, Veverka and Li, 2015).

The equipment to mine the resources, however, is largely purchased from mining equipment providers. These equipment providers include a multitude of different companies as well. The market thereby is led by ThyssenKrupp with a 24% market share and followed by Sandvik (8%), FAM and Takraf (both 7%), making up for almost half of the entire mining equipment market. The other half of the market is made up by a large number of smaller suppliers (Shehata, 2014). Please refer to **Figure 5** for an overview.

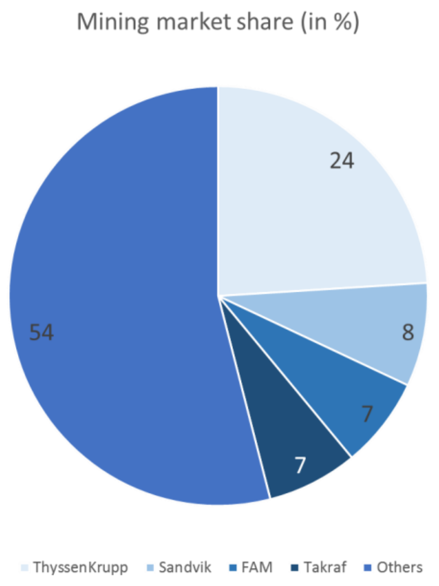


Figure 5: 2014 market share in the mining equipment market (Own figure based on Shehata, 2014)

The market size for mining equipment is highly reliant on the developments in the mining industry, which is very volatile and highly dependent on global economic developments such as commodity prices, which again are dependent on global demands (Butler, Fletcher, Rossouw, Pretorius, Learmonth, Ravi and Sergievsky, 2014; The Mining Association of Canada, 2014). Recently, for example, the backdrop in the Japanese economic growth, the slowdown of the US market recovery as well as the financial issues in Greece and politically unstable regions such as the Russian-Ukrainian border or the Middle East have had and continue to have a major influence on the mining industry (The Mining Association of Canada, 2014; Hopwood, Lane, Demidow, Hughes, Ives and Quinlin, 2015).

These developments have caused capital expenditures from the mining companies to drop as well. In 2014 they dropped by more than 10% (Gravelle et al, 2014), which aligns with a decline in 2013 in the same dimension as well as declines by about 15% in 2015 (Brorson, Maidi, Stettler and Vos, 2015). Despite the negative effects on the mining as well as the mining equipment industry, opportunities through recoveries of markets in Europe as well as the (not fully explored) possibilities in emerging markets, especially in China and India, promise possibilities for a turnaround in this business area (Hopwood et al, 2015). The market for mining equipment, therefore, after a drop down to seven billion Euros in total until today, is expected to slowly stabilize at this level. Moderate growth up to roughly eight billion Euros is not expected until 2019, however (Shehata, 2014). Please refer to **Figure 6** for further details.

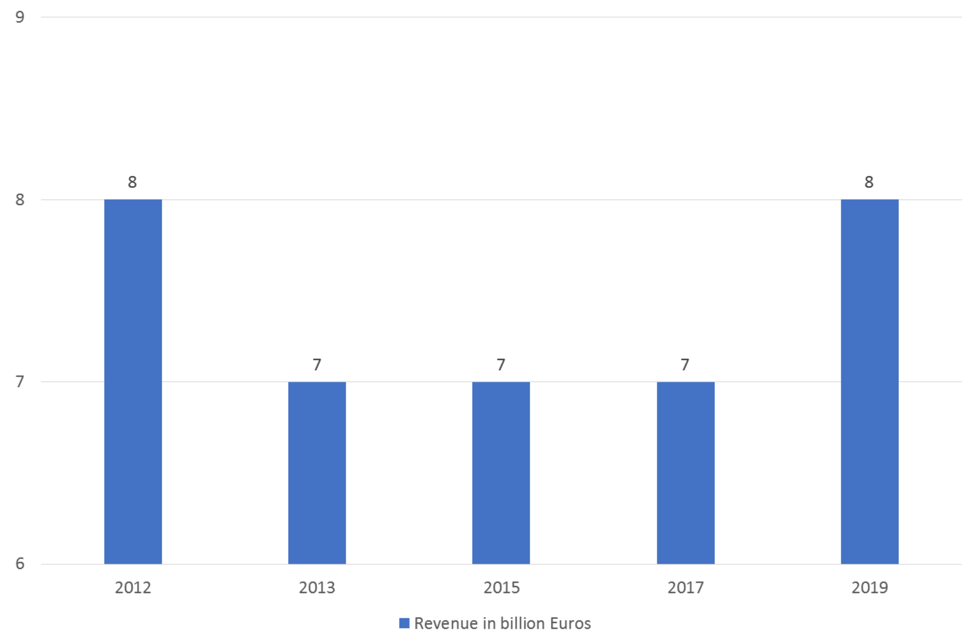


Figure 6: Market size development in the mining equipment business area (Own figure based on Shehata, 2014)

While in the past, capital expenditure cuts as well as headcount reductions seemed to be suitable in order to reduce costs, this, according to Gravelle et al (2014), will not overcome the issues in the long run. Gravelle et al (2014) state, that much rather, to generate growth again, it is essential for mining companies to focus on sustainable improvements in the overall equipment efficiency (OEE), which implies the need for state-of-the-art after-sales service including spare parts logistics and maintenance in order to keep the mining equipment productive at all times. This is supported by EYGM Limited (2014), which states that a clear and especially continuous trend can be seen for increased margin generation through maintenance services in mining. This, according to the analysts, mainly results from the need to extend lifecycles of equipment as the financial situations of the major players in the uncertain mining market, which is facing fiercer competition year by year, does not allow for major investments into new equipment. Utilization of existing equipment is therefore a priority.

1.2.4 IT hardware business area

The information technology (IT) hardware business area has had a very rapid development over the past 30-40 years, especially in the personal computers (PC) market. Starting from large-capacity computers and host systems, over the last decades, this industry has developed into a wide range of diversified stationary PCs as well as portable laptops in more recent history. The advancements of laptops has since even emerged into even smaller mobile devices, such as cell phones and tablets, to include even more technology on even less space and to become a major influence both in the private as well as the business sector for end-users and companies (Evershed and Roper, 2010). In today's environment, IT hardware is not only focused on PCs and mobile phones/devices, however. A lot of other IT hardware has emerged over the last decades to become predominant in today's business and private life and to react to global trends as well. This hardware for instance includes devices such as printers (Jarzemsky, 2011), banking IT hardware such as automatic teller machines (ATMs) and cashier equipment (Takala and Virén, 2007) and any other device or equipment that can be linked to IT.

Especially within a business context, IT has thereby emerged to be an indispensable factor to work more efficiently and effectively (AON, 2012) as well as being a major source for innovation and thus boosting economic growth (Bilbao-Osorio, Dutta and Lanvin, 2014).

Rivera and Goasduff (2015) state that the IT market has been expected to reach a volume of approximately 3.5 trillion USD in 2015, which is 5.5% less than in 2014.This downturn, however, according to the authors, can mainly be explained through currency fluctuation effects and is not considered as a major upset. Devices, such as the above mentioned laptops, tablets, printers, etc. account for approximately 650 billion USD in total spending in 2015, which accounts for roughly 19% of total IT spending. The major contributor to the overall spend in this sector is communication services with approximately of 1.5 trillion USD or 43% of the entire projected IT spending in 2015. Out of the five major sub groups of the IT investments, IT services account for roughly 914 billion USD (26%), making it the second most important sub category in the IT business area (see **Figure 7**).

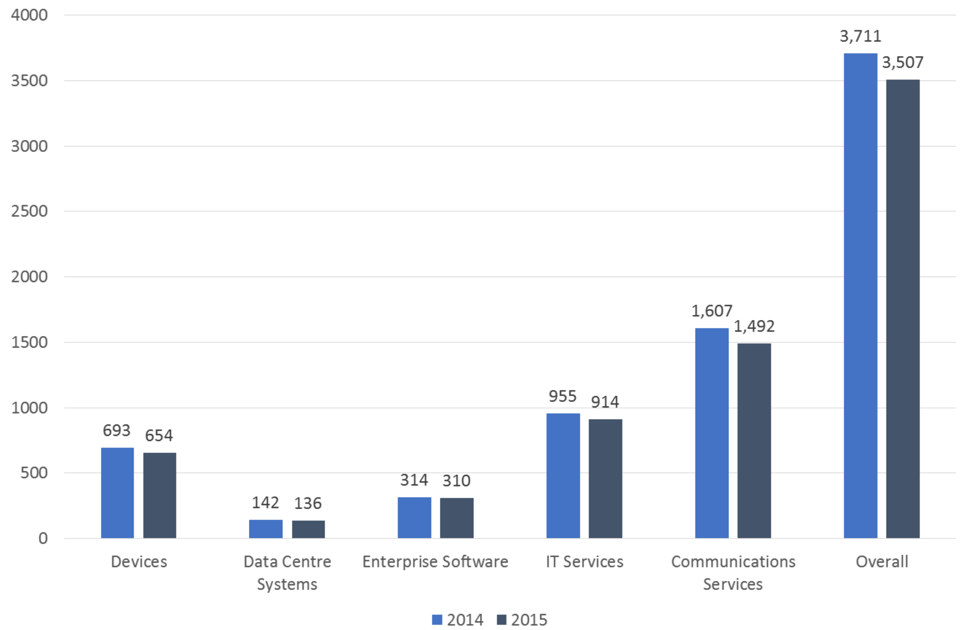


Figure 7: 2014/2015 total IT market in billion USD (Own figure based on Rivera et al, 2015)

The downturn of nearly 6% between 2014 and 2015 in the devices segment is supported by Hariharan, Chen, Park and Rajwanshi (2015), who also state, that this downturn mainly derives from a decline in desktop PCs on the one hand. Laptops and tablets on the other hand, according to the authors, will remain a steady sales and margins distributor in the next years, however. In the printers market, for instance, and as stated by Jarzemsky (2011), sales are also declining and competition to win customers has drastically increased for providers.

In both the commodity-like market of PC-IT hardware (Hölbling, Engelmann and Nedelchev, 2009), where the major players namely are HP, Lenovo, Dell, Acer and Asus (Euler Hermes, 2013), the printer-IT hardware market, where the major competitors are Xeros, HP, Ricoh, Canon as well as Konica Minolta (Jarzemsky, 2011; Statista, 2015d), as well as any other IT hardware industry, e.g. the banking IT hardware market, diversification plays an especially important role for providers in order to achieve a competitive advantage in the context of today's business environment (Porter, 1985; Christopher, 2010; Jarzemsky, 2011). Apple's latest idea to revive the IT hardware market, for instance, therefore is the launch of a larger iPad for instance (Hariharan etal, 2015). Dell as another example diversifies itself from the competition by building customized PCs and laptops, thereby outsourcing a major amount of processes such as components supply, logistics and distribution as well as repair and maintenance support to subcontractors (Kraemer and Dedrick, n.d.). Similar trends of new technological advancements utilization as diversifiers are visible also in the printer market (Jarzemsky, 2011).

Especially improved after-sales services, according to Hölbling et al (2009), however, offer high potential for diversification and thus a competitive advantage and increased margins in this business area. By improving and creating high quality and economically acceptable warranty, repair, maintenance and recycling concepts, companies cannot only gain additional direct margins, but cross selling opportunities rise as well. The authors state that 90% of the consumers interviewed for a study by market research firm Vocatus for B2X Care Solutions mentioned that the quality of the after-sales service had an impact on future purchases for them (Hölbling et al, 2009). Then looking at the customer satisfaction of the respondents to the services provided by IT after-sales service providers, only 25% were satisfied with their recent IT service experiences (Hölbling et al, 2009). In that context, when looking at the market potential of IT services in general, which, according to Rivera et al (2015) are the second highest contributor to the huge overall IT market sales (see **Figure 6**), service and especially after-sales service including spare parts logistics and maintenance seem to be a major opportunity for companies to focus on in the IT hardware business. This is supported by Statista (2016), which in their analysis for 2016 show that whilst revenues generated through IT hardware decrease dramatically, revenues generated through services remain stable (see **Figure 8**).

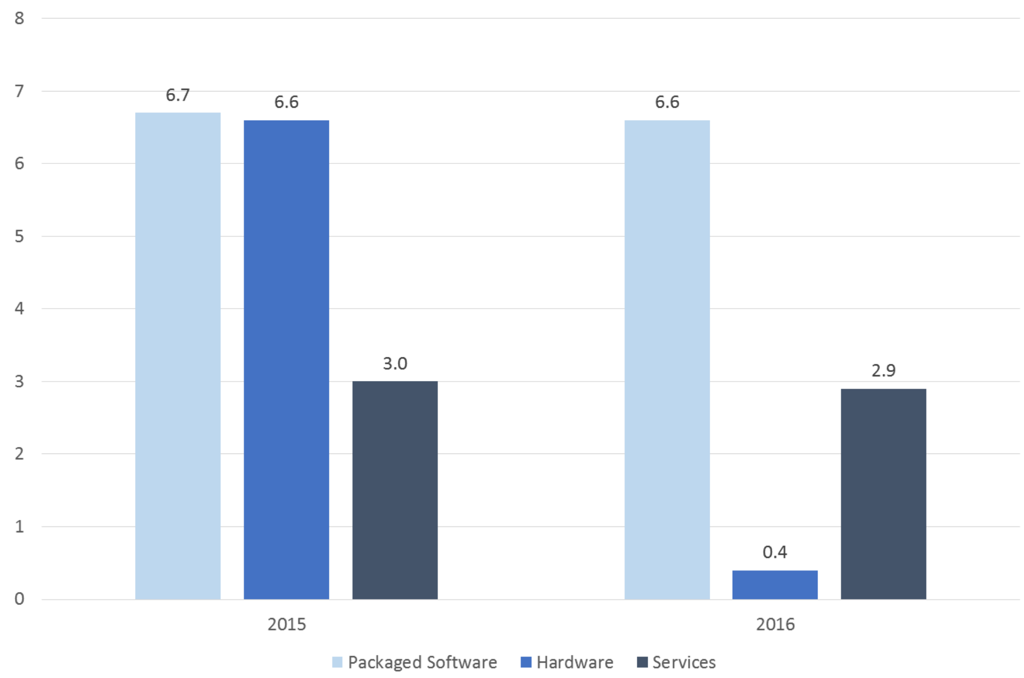


Figure 8: Growth in % of IT spending worldwide in 2015 and 2016 (Own figure based on Statista, 2016)

1.3 Research sequence

Chapter 1.1 and Chapter 1.2 indicate that servitization plays an especially important role in today's market oriented business environment in order to generate competitive advantages and create revenues. Here, specifically the role of after-sales services such as spare parts logistics, maintenance, etc. could be identified as a lever for companies to diversify themselves from the ever-growing competition and challenges. It is therefore the goal of this thesis to identify a gap in literature and research in the context of optimizing after-sales service, to contribute to closing this gap and thus creating a benefit to knowledge and business practice by making a contribution to the lever that this industry holds.

Having introduced the importance as well as highlighting the potential for improving competitiveness through after-sales services such as spare parts logistics, maintenance, etc. in general and in three different business areas in **Chapter 1**, **Chapter 2** focusses on the literature review conducted in order to identify a gap in research in this field. Whilst a large amount of research has been done in this field already, after an in-depth study of available literature in the area, a gap in literature and thus potential for further research becomes evident.

The literature review thereby covers topics such as operations management, operations strategy and their link to servitization and the importance of after-sales services in servitization as a relevant business strategy in today's business environment. Furthermore, spare parts logistics management is then identified as specifically relevant to the topic. In spare parts logistics management, the relevance of downtime reduction is discussed in detail as well as the factors which influence corrective maintenance response times to broken down units. These factors are furthermore looked at in depth in order to identify research gaps and potentials.

The further research need, which will be covered by this thesis and which is derived through the literature review, is addressed through four research objectives and four research questions. The focus area thereby is the development of a consensus construction to understand and improve factors affecting service technicians'/fitters'/engineers' response time performance in stationary equipment corrective maintenance. By addressing this research gap, it is the intention to contribute both to knowledge as well as business practice.

Chapter 3 focusses on the research philosophy of the author, which is essential for the choice of research methodology and methods utilized to answer the research questions and to fulfill the research objectives. The choice for an abductive, qualitative, multiple case study approach will be explained and justified. Adjacently, the according research design for the empirical part of the research will be discussed.

Four phases are thereby defined for the empirical research and are explained in detail. These four phases include the description of the research preparation as well as the outline of a pilot study, the conduction and documentation of the different cases, the analysis and interpretation of the results as well as the development of a consensus construction. Furthermore, they include drawing conclusions and recommendations, a description of limitations and an outlook on further research.

Chapter 4 contains the detailed description and analysis of the findings from the empirical research. This chapter will be subdivided into the four sub-chapters described in **Chapter 3**. Firstly, the preparation as well as the pilot interview will be described in detail in order to rectify the chosen approach and to validate the appropriateness of the outcomes both for knowledge as well as for business practice. In the second phase, the three cases conducted for this research, i.e. elevator, mining equipment and IT hardware, will be explained in detail and differences as well as similarities from the cases will be outlined. For the cases themselves, process observations, expert interviews as well as available data and further literature are included. The third step in this chapter is the in-depth analysis of the research outcomes as well as findings. Accordingly, this part also includes the generation of the consensus construction that can be utilized to improve corrective maintenance response time for stationary equipment in the community studied. The chapter is closed off by concluding the empirical findings and highlighting the contributions of this research to both knowledge as well as business practice, giving recommendations, highlighting limitations and outlining potential further research in this area.

1.4 Motivation for research

With this thesis, it is the author's intention to contribute knowledge both to research as well as business practice. Additionally, by conducting this research endeavor, it is the author's goal to develop himself further as a researcher and to become an expert in a topic both relevant for research as well as business practice.

Throughout his university career, the author especially enjoyed working on the respective theses that were required in order to fulfill the curriculums. He wrote his Bachelor thesis about logistics processes together with a forwarding company. For the Master degrees the author wrote a thesis on process optimization for an aviation consultancy in Germany and a second one on portfolio optimization and relocation of units for a large multi-national company in the United States.

What made the author particularly enjoy writing these theses were a couple of factors: First of all, the topics that were written about were of very high interest to the author and have been throughout his studies and work life, i.e. after-sales services and (process) optimization. This is the case for this thesis as well. Second of all, the topics covered always focussed both on topics relevant in research, but also in business practice. The concept of identifying research needs in available literature and contributing to closing the gap through projecting it into real business scenarios, then solving the issues through empirical research together with highly skilled experts in their respective fields of business and finally generating outcomes relevant both for business practice as well as research have always been a logical approach for the author.

In order to not only contribute to knowledge and business practice, but to also develop himself personally, the author's goal set to himself in this context is to become a T-shaped professional (Heinemann, 2010), which is displayed in **Figure 9**.

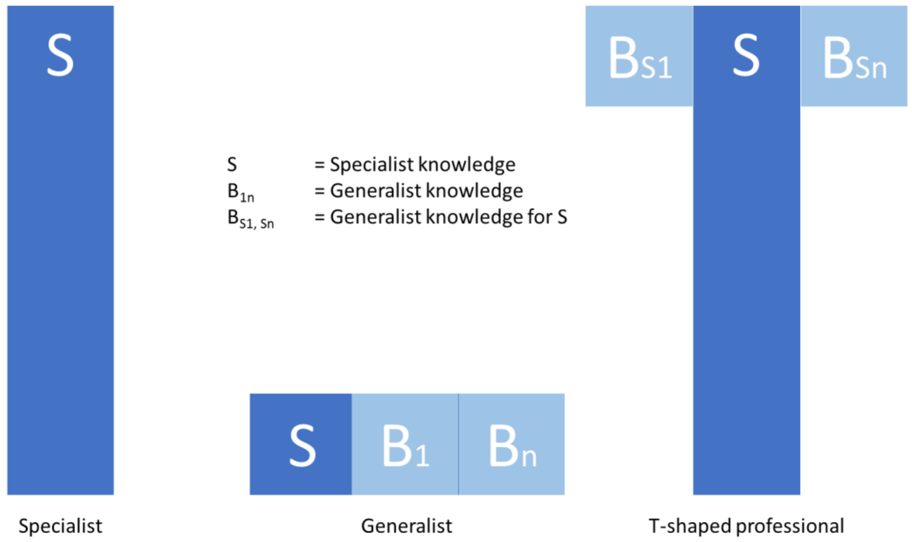


Figure 9: T-shaped professional (Own figure based on Heinemann, 2010)

As stated by Heinemann (2010), the T-shaped professional combines the strengths of the specialist and the generalist. The goal in this concept is to gain general knowledge on the one hand, but on the other hand to become an expert in a certain area. For this specialist area, in order to be successful, it is again essential to also create a broad and general knowledge base surrounding it and creating the three parts of the T-shaped manager or professional.

In order to achieve this, on the generalist side as well as the generalist side for specialist knowledge, the author continuously develops himself in the company he works for through new fields of operations, projects, trainings and responsibilities. The specialist/expert side is covered by the doctorate, which aims at generating new knowledge in a very specific field that has not yet been fully explored. The ultimate goal of this approach is to enhance the author's knowledge in a way that he can contribute on an expert level both in knowledge as well as in business practice.

2 Literature review

2.1 Aim and approach

The aim of this literature review is to understand what kind of research in the field of after-sales service and especially spare parts logistics management exists. Furthermore, it is the intention to understand what kind of literature exists with respect to optimization in these areas in order to generate a benefit for companies aiming to improve based on the need described in the introductory chapter. The goal is to build a consensus construction around a gap that needs further attention and research in this field of interest and thus contributes to knowledge, but also business practice.

According to the approach suggested by Tranfield, Denyer and Smart (2003), i.e. systematic literature review, in a primary step a scoping study was conducted in order to get a first overview of the available literature in the field of interest, i.e. after-sales service and spare parts logistics optimization. Additionally, the scoping study was used to set limits to the topic for the extensive literature review. This preliminary piece of work was handed in as an assignment at the University of Gloucestershire and graded and confirmed by two professors in order to validate the direction for further research. The author's doctoral supervisors also approved this assignment. Additionally, the status of this preliminary literature review was discussed both in Action Learning Sets (ALS) with other doctoral candidates as well as experts from the author's employer. In a second step, a detailed literature review was therefore conducted in order to identify a gap in research in this area and to define the according research questions and objectives. This extensive literature review will be described in this chapter. It was started at the end of 2013 and finalized in spring 2014 to create a starting point for the research. The author appreciates the fact that research has continuously moved on after this literature review was finalized and a starting point for empirical research was generated. He therefore continued to regularly screen literature throughout the entire research process. Inputs, which were seen as an important data point for this thesis were therefore included in the respective parts of this study, wherever appropriate.

Management reviews, as Tranfield et al (2003) suggest, are usually based on a flexible process and a development through exploration and findings rather than a pre-set and fixed research question right from the beginning. Literature for this review was therefore searched in an iterative process by using English and German search terms, looking at titles and abstracts of papers as well as cross-reading the abstracts, papers and bibliographies in order to generate new possible search terms and combinations of search terms that were then looked up again. The main search terms were the following[1]:

[1] German search terms were translated from English search terms wherever/whenever appropriate.

- (After-sales) service
- (Servitization) strategy
- Product-service systems (PSS)
- Service operations
- (Service) operations management OR strategy OR performance
- Service sciences
- Service quality
- Logistics (management OR processes OR optimization)
- Service OR spare parts
- Service OR spare parts management
- Service OR spare parts logistics
- Service OR spare parts optimization
- Service OR spare parts identification
- Process management
- Process optimization (in (service OR spare parts) logistics)
- Service process optimization (in (service OR spare parts) logistics)
- Service OR spare parts process (optimization)
- Trends in (service OR spare parts) logistics
- Information logistics (in (service OR spare parts) logistics)
- Maintenance, Repair and Overhaul (MRO) (in (service OR spare parts) logistics)
- Corrective OR preventive maintenance
- Order management
- Inventory management
- Multi-echelon ((service OR spare parts) logistics networks)
- Service OR spare parts provisioning
- (Service) response time OR downtime reduction
- (Service) response OR throughput OR waiting time (in (service OR spare parts) logistics)
- Time-based service level
- Service technician OR engineer OR fitter
- Human resources in service OR logistics OR supply chain management

These search terms were entered in relevant electronic databases such as ABI/INFORM Global, Business Source Complete, EBSCO eBook Collection, SAGE Research Methods and Science Direct among others. Additionally, the online thesis database EThOS from the British Library was searched as well as the catalogs of the University of Duisburg-Essen, Dortmund University of Technology and the Bavarian State Library. Online sources such as Google

Books, Google Scholar and relevant homepages or online documentation were also involved in the search.

This iterative process resulted in a large variety and quantity of literature for the review, which is organized in the following chapters and leads to the research gap and consequently the research objectives and questions of this thesis.

2.2 The importance of servitization for spare parts logistics management

2.2.1 Operations management

According to Slack, Chambers, Johnston and Betts (2009) and Slack, Brandon-Jones and Johnston (2014), the reason to exist for any company is to generate products and/or services and fulfill customer demands by delivering those products and/or services to them. Dealing with all the resources and processes between a customer demand and the delivery of a product and/or service is the activity of operations management. According to the authors, as all organizations generate products or services in one form or another, all of them have operations and thus need to manage them. They further state that besides marketing and sales, which deal with communicating and advertising a firm's offering, as well as product and/or service development, which generates customer demands, operations management is the third key function and also the most important in any organization, because it handles both the creation as well as delivery of products/services, according to the customer demands generated earlier by steering and managing resources and processes. Furthermore, every department, e.g. Finance, Engineering, Marketing, Human Resources, Production, Logistics, Sales, etc. has processes and resources and thus operations that need to be taken care of.

Regardless of the size of the company, managing these resources and processes to fulfill customer demands needs to happen efficiently and effectively in order for the companies to remain competitive. If operations are not efficient and effective and demands cannot be met by a company, competitiveness and eventually financial performance and success may be risked (Slack et al, 2009, Slack et al, 2014).

In order to manage and/or improve the operations performance of a company continuously, clearly defined objectives and competitive priorities with regards to the market are necessary (Drohomeretski, Gouvea de Costa, Pinheiro de Lima and da Roa Garbuio, 2014; Slack et al, 2009, Slack et al, 2014). These vary between different authors. As shown in a comprehensive overview by Drohomeretski et al (2014), Wheelwright (1978, as cited in Drohomeretski et al, 2014) names efficiency, reliability, quality, flexibility, speed and cost, while Leong, Snyder and Ward (1990, as cited in Drohomeretski et al, 2014) consider only quality, delivery performance, cost and innovation to be the main objectives of operations management, performance and strategy. Furthermore, Drohomeretski et al (2014) list Slack (1991, as cited in Drohomeretski et al, 2014) with quality, reliability, flexibility, speed, cost and innovation as well as Garvin (1993, as cited in Drohomeretski et al, 2014) with quality, reliability, flexibility, speed, cost and services.

Widely accepted to be the main and central competitive objectives by a number of authors (e.g. Santos, 2000; Slack et al, 2009; Hayes and Wheelwright, 1984, Fine and Hax, 1985 and Ward, McCreery and Ritzman, 1998 as cited in Szász and Demeter, 2013; Avlonitis, Frandsen, Hsuan and Karlsson, 2014; Slack et al, 2014) are cost, quality, speed, dependability and flexibility. This is displayed in **Figure 10**.

Figure 10: Competitive priorities/objectives in operations management (Own figure based on Slack et al, 2014)

According to Slack et al (2009) and Slack et al (2014), quality advantages can be generated through goods or services that are demerit-free and according to the needs of the customers. Dependability advantages can be generated when delivery or production dates are met and by ensuring availability. Flexibility advantages can be realized by being able to change operations in a way that they can handle unexpected circumstances, such as short-notice customer changes to the product and/or service. Cost advantages may be achieved by demanding a price that reflects the value of the product and/or service, which is more attractive than the prices of the competition for similar products/services and still economically reasonable in order to generate profits. Last but not least, speed advantages can be created by reducing the time between a customer demand and the delivery of a product/service to the customer.

Trade-offs between those objectives can occur, however. The concept of trade-offs thereby goes back to Skinner (1969), as stated by numerous authors (e.g. Lapré and Scudder, 2004;

Avella, Vazquez-Bustelo and Fernandez, 2011; Schroeder, Shah and Peng, 2011; Slack et al, 2014) and states that improvements in one of the objectives can only be achieved through potentially sacrificing the status of one or more of the other factors. Ferdows and de Meyer (1990) challenged this by stating that the competitive objectives have to be improved in a certain cumulative order in order to reduce or even eliminate the trade-off effects. They have called this approach the sand cone model. While their model focussed on quality, dependability, speed and cost, a version of this model including flexibility has been generated by Slack et al (2014). This is displayed in **Figure 11**.

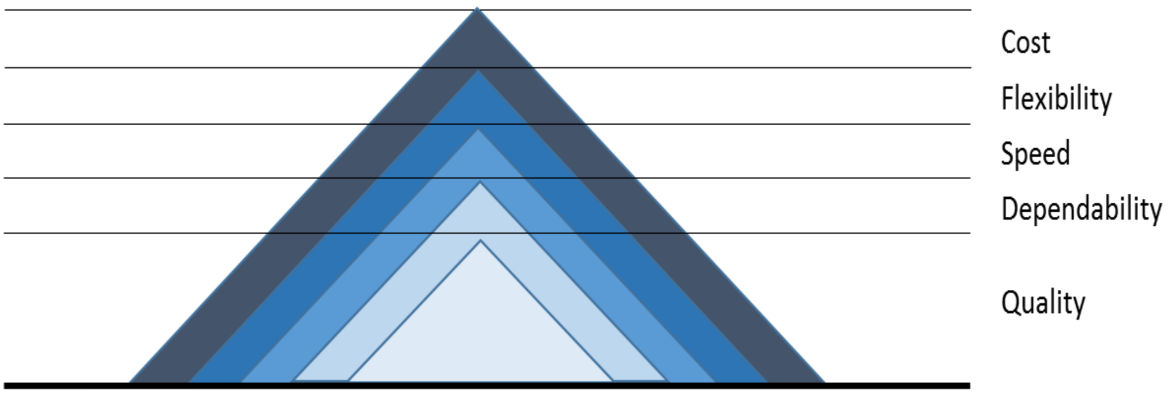


Figure 11: Sand cone model (Own figure based on Slack et al, 2014)

The order in this model relies on quality improvements as a base requirement first, followed by improvements in dependability, speed, flexibility and finally costs, moving to the next level only when the according minimum acceptable level of improvement has been realized in the prior objective (Slack et al, 2014). The authors emphasize, however, that this approach is cumulative and not sequential, i.e. beginning to improve dependability for instance should not stop continuously improving quality.

Another approach to generate the desired results, according to Slack et al (2014), is based around focussing on the specific needs, requirements and circumstances of a certain operation. Here, according to the authors, it is therefore important to target those specific needs through the best suited competitive objective and then find the right balance between the other objectives and their improvements in order to remain efficient, effective and competitive while advancing operations to generate higher customer satisfaction and ultimately higher revenues.

Especially in today's business environment, where companies are confronted with a constant need to change and improve in order to stay competitive, a focus on the competitive operations objectives through an operations strategy is essential (Drohomeretski et al, 2014; Liu and Liang, 2015). The operations strategy thereby, according to Szász et al (2013), acts as the backbone of a company to improve the operations and thus competitive priorities, which need to be clearly identified and formulated (Slack, 1994) and need to be closely linked to the company's business strategy.

2.2.2 Introduction to servitization

The globalization with the effects of high amounts of diverse competition, the constantly rising customer demands, technology improvements and the influence of cost pressure on the generation of margins, among others, have been major reasons for manufacturing companies and equipment providers in the past decades to change their business strategy from production orientation to market and customer orientation in order to stay competitive and successful in their respective markets (e.g. Vandermerwe et al, 1988; Wise et al, 1999; Mathieu, 2001a; Oliva et al, 2003; Gebauer, Fleisch and Friedli, 2005; Cohen, Agrawal and Agrawal, 2006; Brax and Jonsson, 2009; Gebauer, Pütz, Fischer and Fleisch, 2009; Christopher, 2010; Gebauer et al, 2012; Kinnunen and Turunen, 2012; Kastalli and van Looy, 2013; Drohomeretski et al, 2014; Smith, Maull and Ng, 2014; Liu et al, 2015).

In order to become market and customer oriented, thus moving away from simply producing and shipping goods to the far more complex (service) operations of designing and delivering customer solutions (Durugbo, 2014; Smith et al, 2014), companies have to go through a process of servitization (Kinnunen et al, 2012) by adapting and improving their strategies and principles, organizational structures and processes to meet customer needs and requirements at all levels (Baines, Lightfoot, Peppard, Johnson, Tiwari, Shehab and Swink, 2009; Gebauer et al, 2012). Servitization as a term used to explain the aims and also needs of manufacturing companies to add value to their product portfolio through services was first used by Vandermerwe et al in 1988. They realized the trend, and are supported by other authors (e.g. Wise et al, 1999; Gebauer, 2007; Gebauer et al, 2012), of companies trying to focus more on the customer needs and thus offering not only their products as standalone solutions, but also adding service, support and knowledge for the product to add value, to differentiate themselves from the competition and to create a competitive advantage. According to the authors, in the course of time, for businesses and/or their respective managers it quickly was observed that products and services need to be seen in cooperation, complementary and as a holistic solution for the customer rather than focusing on either the product or the service separately and excluding the other in order to be successful. Whereas in the past, companies were divided into a goods or a service company, with the evolution of technology as well as other trends, manufacturing companies started to merge both services and products. Today in most areas of business, their portfolio even goes beyond the product and its service, i.e. maintenance, and integrates support such as training, know-how such as applications or even self-service functions in order to create a full experience around the product and thereby satisfy the customer.

Examples of multinational manufacturing companies that have adapted successfully towards the market and customer driven business environment through servitization include Volvo (Vandermerwe et al, 1988), Merck and Glaxo (Quinn, Doorley and Paquette, 1990), HP and Ericsson (Roland Berger Strategy Consultants, 2010), IBM (Roland Berger Strategy Consultants, 2010; Ahamed, Inohara and Kamoshida, 2013; Paiola, Saccani, Perona and Gebauer, 2013) as well as Xerox, General Motors, Apple, Volkswagen, Caterpillar, Johnson and Johnson (Gebauer et al, 2012), Rolls-Royce Aerospace and ABB (Kastalli et al, 2013), Alstom, General Electric, John Deere and Siemens (Paiola et al, 2013) or Thales (Jovanovic, Engwall and Jerbrant, 2016).

Numerous classification models of structures that combine products and services exist. For instance, Mont (2002), on the one hand, categorizes the so-called product-service systems (PSS) into five groups, namely product orientation/service orientation/combinations/substitutions, services at the point of sale, different concepts of product use (use oriented/result oriented), maintenance services, and revalorization services. Wong (2004) as cited in Baines, Lightfoot, Steve, Neely, Greenough, Peppard, … and Wilson (2007) on the other hand identify pure products and pure services each at one end of the spectrum with a mix or combination of servitization of products and productization of services to varying degrees in the middle. A similar categorization comes from Kotler (2003) as cited in Brax (2005), who puts tangible goods at one end of the scale before coming to tangible goods with accompanying services as a second category. In the middle of the scale are hybrid PSS. The fourth category is filled by major services with minor goods and services that come along with the major service. At the other end of the scale are pure services.

A widely accepted categorization (e.g. Baines et al, 2009; Weissenberger-Eibl and Biege, 2010; Wang, Ming, Li, Kong, Wang and Wu, 2011; Bezerra Barquet, Gouvea de Oliveira, Amigo, Cunha and Rozenfeld, 2013; Smith et al, 2014; Gebauer, Joncourt and Saul, 2016), however, has been introduced by Tukker (2004), who identified eight archetypes of PSS, which serve the companies as their service strategy in order to generate the right service and an added value for the customer. These archetypes are divided into three main groups by Tukker (2004). This is displayed in **Figure 12**.

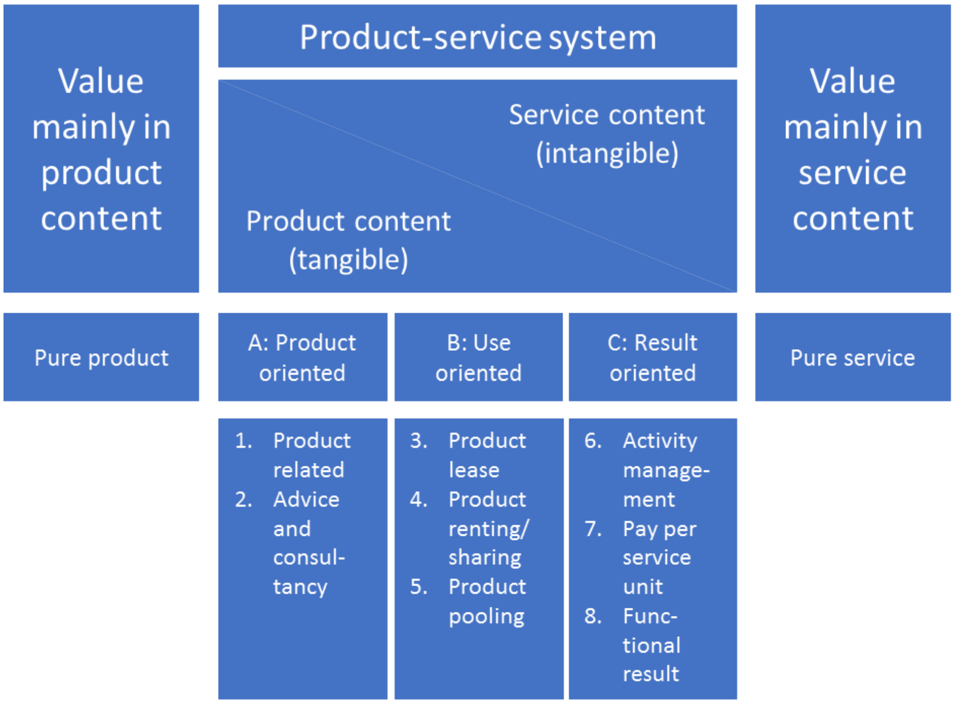


Figure 12: Main and sub categories of PSS (Own figure based on Tukker, 2004)

According to Tukker's (2004) categorization, the first main group includes the product oriented PSS with two sub groups. Product related PSS, which are the first sub group, focus mainly on selling products and adding only a few closely related services such as maintenance, repair and overhaul (MRO). The second sub group of advice and consultancy PSS implicate that in addition to the product, the manufacturer also gives support in order for the customer to use the product in the best and most efficient way possible. The second main group of use oriented PSS includes three sub groups, the first one being product lease. This means that the manufacturer maintains the ownership of the product and is also responsible for its functioning throughout its lifecycle. The customer leasing the product will be charged a fee for the use of the product and usually does not change. The main difference of the second sub group of product renting PSS is that the customers that use the product may change over time. Product pooling, which is the third sub group, includes the simultaneous use of the same product by different customers. The third main group of result oriented PSS also includes three sub groups. The first one, activity management PSS, handle the outsourcing of services to a third-party provider. In the second sub group, which are the pay per service unit PSS, the customer does not buy the product but pays a certain fee in accordance to the output of the product. This is also known as the power-by-the-hour concept, which was first used by Rolls-Royce (Jovanovic et al, 2016). The last sub group of functional result PSS is the most flexible in its definition as both the customer and the manufacturer agree on a delivered result through the product, which is paid for by the customer (Tukker, 2004). According to Tukker (2004) as well as Panizzolo (2008), it is important for a company to know and realize which PSS is best suited for its business model and strategy, as both the costs and risks when implementing it within the manufacturing company, as well as the impacts on the tangible and intangible value creation for the end user, vary between each PSS. This means that not just any service helps, much rather it has to be the right service that creates an advantage for the customer and through that also for the manufacturer.

2.2.3 Benefits and obstacles of implementing servitization

Benefits of servitizing and offering PSS to the customer, on the one hand, are highly attractive and are usually divided into three main areas that can be impacted through the addition of services to products by manufacturing companies. Namely those categories are benefits through strategic, financial and marketing possibilities (e.g. Mathieu, 2001a; Mathieu, 2001b; Gebauer et al, 2005; Gebauer, Krempl and Fleisch, 2008; Gebauer, Edvardsson and Bjurko, 2010; Kinnunen et al, 2012).

Strategic benefits of servitization especially include the opportunity to approach the customers in an efficient and quick way through a pool of new and different services to be added to the company's (product) portfolio and through internal process and performance measures that support this aim (Vandermerwe et al, 1988; Tukker, 2004) in order to add value to the company's tangibles offered (Mathieu, 2001b). Tukker (2004) also identifies the possibility to innovate faster, as through the products, services and the relationship that is generated through servitization, the company knows exactly what else a consumer could want both in products and service. Additionally, not only does this help to better approach customers, Vandermerwe et al (1988) further suggest and are supported by Oliva et al (2003), Brax (2005), Gebauer, Krempl and Fleisch (2008) and Kinnunen et al (2012) that through this, entirely new business fields and opportunities can be approached by the company and barriers for competitors can be built. This again might help to strengthen and grow one's own position in the market while simultaneously competitor's positions can be attacked and weakened. Overall, according to Gebauer, Krempl and Fleisch (2008) and Kinnunen et al (2012), this enables the manufacturing companies to differentiate drastically from the competition in order to gain a competitive advantage and through this possibly regain the attention of old customers as well as attracting completely new customers. Another major strategic benefit of servitization is the possibility of cooperation, through which a focus on core activities and risk sharing with customers can be achieved (Oliva et al, 2003; Kinnunen et al, 2012).

Marketing benefits that add on to that include the customized and holistic response of offering products and services to customer demands and the convenience it generates for them (Vandermerwe et al, 1988; Brax, 2005; Kinnunen et al, 2012). Through this, a further risk reduction for the customer is generated by the provider. Especially for expensive products, where the impact of malfunctioning would cause the need for a lot of additional expertise, know-how or costly processes to find support, the customer through servitization is now fully served by the manufacturer of the product with know-how and service as requested (Brax, 2005; Kinnunen et al, 2012). This again helps the servitized company to bind the customer and build long lasting relationships that result in additional profit (Vandermerwe et al, 1988; Gebauer, Krempl and Fleisch, 2008; Kinnunen et al, 2012).

Furthermore, financial benefits can be achieved through servitization. Gebauer, Krempl and Fleisch (2008) suggest and are supported by Oliva et al (2003), Brax (2005) and Gebauer et al (2005) that offering a service in addition to a product provides the company with a stable income source. Whereas the sale of products may vary due to numerous reasons, e.g. demand cycles or economic barriers, service is a stable and often contractually reoccurring source of revenues and margins, e.g. through regular maintenance,. Furthermore, services generally offer higher margins than products (Oliva et al, 2003; Gebauer et al, 2005; Cohen et al, 2006; Gebauer, Krempl and Fleisch, 2008) and also boost product sales (Kinnunen et al, 2012). Overall, a higher financial flexibility and reliability in economically unstable situations as well as new markets can be generated through servitization rather than pure product focus (Kinnunen et al, 2012).

On the other hand, many authors (e.g. Vandermerwe et al, 1988; Oliva et al, 2003; Gebauer, 2007; Gebauer et al, 2012, Kinnunen et al, 2012) identify high obstacles to overcome for manufacturing companies in order to servitize. Gebauer et al (2012) as well as Oliva et al (2003) for instance identify the challenge that when a service offering is developed and implemented by a manufacturing company, it usually has effects not only on the service level for the customer, but also for the internal organization, such as its processes, the research and development (R&D) department as well as the design and production of further capital goods, the human resources and the company's overall strategy and approach to service the market. This again may have major impacts on the overall performance of the manufacturer (Kastelli et al, 2013). Gebauer (2007) focusses explicitly on the challenges and difficulties associated with the need for the human resources to adapt to the changed mindset away from production focus to market and customer focus. Oliva et al (2003) on the one hand add that the incentive system on an individual level has to be restructured in order to overcome internal resistance. Mathieu (2001b) on the other hand believes that the impact of service implementation is noticeable especially on a political level, i.e. entire departments or business units. Whereas some will encounter opportunities through the new service focus, others will fear the loss of authority. This argument is supported by Kastelli (2013), who believes that the lack of attention from the senior level and top level management can have a negative impact on the implementation of servitization. Also, this effect will be strengthened as servitization is an innovative process within the company and innovations also tend to show the risk of not being accepted everywhere to the same extent within (manufacturing) companies (Mathieu, 2001b). Kinnunen et al

(2012) beyond the internal threats in change, and especially the risk for resistance within the company to change, additionally identify the new role in relationships towards the customers as major obstacles to implement a service oriented manufacturing company. Additionally they suggest that defining the right service and managing it properly through communication, knowledge management, etc. are two other major hurdles to overcome. Gebauer (2007) furthermore suggests for any manufacturing company that aims to servitize to create an entirely new business unit focusing on the service towards the customer. This has high impacts on the company's structure and organization and is connected to high change management efforts as well. Vandermerwe et al (1988) add that beyond those factors, new marketing tools, transportation methods, relationships with external companies supporting one's new business model, IT interfaces and methods to distribute information have to be considered. Mathieu (2001b) also suggests further challenges that need to be considered. She states that when adding service to products, a new competitive market with new challenges and challengers needs its fair share of attention.

2.2.4 Implementation steps in servitization

According to Gebauer et al (2005) as well as Gebauer et al (2016), the implementation of servitization does not only involve high obstacles to overcome, but oftentimes promotes a paradox in itself for a lot of manufacturing companies. The authors explain that when a manufacturing company invests in developing service to accompany their product, it has to invest in this service or these services, which again generates higher costs. These costs and investments, however, do not automatically result in higher returns and revenues. It is important that there is a transition from being a product manufacturer to becoming a service provider. This means that a high amount of the total value that is created for the customer comes from the service business, e.g. maintenance, repair and overhaul (MRO), support and know-how transfer, trainings, etc. If, however, there is no real transformation and much rather the services maintain an add-on to the products, the strategy of servitization oftentimes fails and the company generates the so-called service paradox. This turns out to be unsatisfactory for most companies, as the realized margins are far below the expectations and do not necessarily justify the investments made in servitization. Please refer to **Figure 13** for a graphical display of the service paradox, according to Gebauer et al (2005).

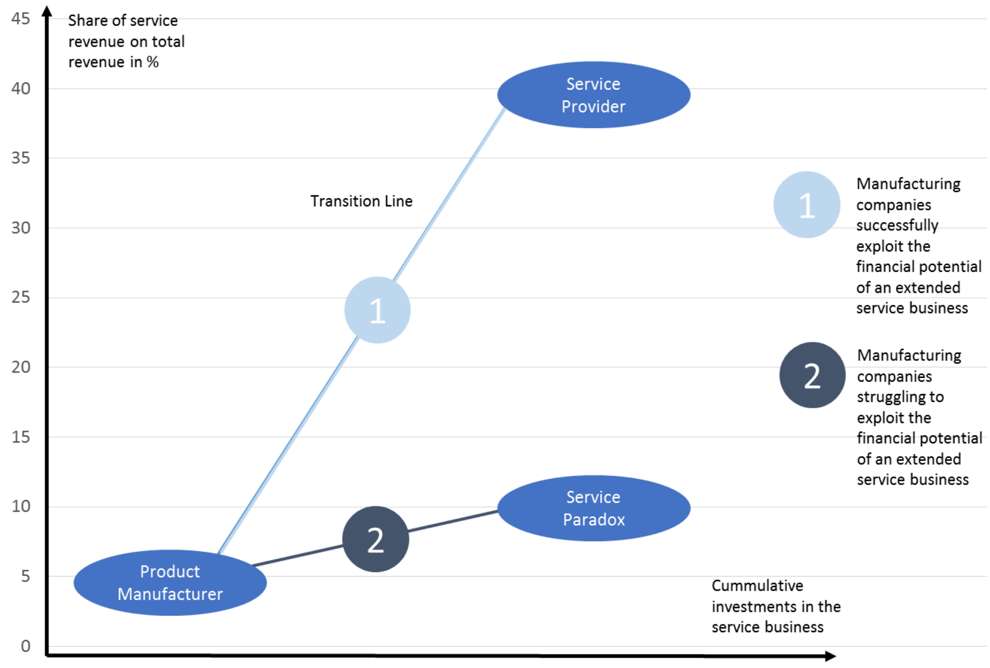


Figure 13: Transition line and service paradox (Own figure based on Gebauer et al, 2005)

It is therefore important to follow the right steps when aiming for servitization (e.g. Oliva et al, 2003; Gebauer et al, 2005; Gebauer, 2007; Gebauer et al, 2009; Kinnunen et al, 2012).

Oliva et al (2003) provide a framework with four major phases for manufacturing companies to go through during the process of servitization. As a first step they suggest to consolidate all existing product-related services within the company, as very likely some services exist already but are scattered and unstructured throughout the organization. According to Oliva et al (2003), this first step usually is driven by the goal to improve the service efficiency, the quality of services and the delivery time of the respective services offered to the customer. Through the consolidation, the development of the improvements in this sector can be monitored, standardized and harmonized and a full picture of the service market that the company is operating in can be generated.

In a second phase and usually evolving through the monitoring and consolidating in stage one, Oliva et al (2003) suggest to enter the installed base service market in a structured way in order to realize a higher profitability, to be able to better compete with the competitors and to increase customer satisfaction. The two main challenges in this phase are high as a cultural change from product-centric to service-centric management in the organization is required and additionally a service infrastructure needs to be installed at the same time. Usually this is the stage where the service paradox mentioned by Gebauer et al (2005) can create trouble. Both Oliva et al (2003) as well as Gebauer et al (2005) realize that it might be tough for companies that are used to producing complex and highly expensive products to strengthen their focus on achieving comparably small but continuous revenues through the MRO of that equipment and to move away from looking at service as a necessary add-on that comes along for free to the customer with the purchase of a product. At the same time, it is very important to build an infrastructure and organization, which can handle the additional service business, which has the management support, the required human resources, the knowledge and expertise and which is supported by state-of-the-art processes and technologies.

Gebauer et al (2005) identify three main points of focus to successfully overcome these issues. First of all, they find it to be essential to create the managerial motivation to improve the service of the company. Managers have to overcome the overemphasis on differentiation through further products, enhancements or new designs, etc. Instead of using all the resources in this sector, more should be invested in strengthening the service business. Furthermore these managers need to realize the economic capabilities of the service business and they need to find a way to overcome their reluctance and risk aversion towards service success. Overall it becomes clear that only through a mindset change in the management, a mindset change in the organization can be realized.

The second point made by Gebauer et al (2005), who is supported in this argument by Gebauer et al (2009) and Kinnunen et al (2012), is to adapt organizational arrangements in order to successfully implement a structured service business in the manufacturing company. The authors name factors such as defining a clear service strategy within the company, creating a separate organization responsible for service including responsibility for profits and losses, human resources, processes, etc. as well as implementing a service culture, focusing on the customers and the value that can be generated for them, introducing a structured development process for continuously improving the market and customer oriented service as well as initiating relationship marketing. Overall, the organization has to be put into a position that it can handle the change. This credibility issue is extremely important, as regardless of how good a business strategy, i.e. aim to servitize, is, if it is not seen as credible by the people who have to make the change, i.e. the workforce, due to non-existent structures, etc. then it is very likely to fail.

As a third and last point, Gebauer et al (2005) mention that unexpected effects that occur during the implementation need to also be considered. These unanticipated effects may include the so-called credibility gap, which means that the given way forward, which was initiated through the management, needs to be carried out by the workforce. The initial motivation through incentives, etc. soon dissolves in the course of day-to-day business and activities. Only full acceptance through the employees can then overcome this issue. This again can be achieved through initial success, etc. which realizes for the concept to be committed to by the entire company. Further side effects, e.g. the quality erosion of service as well as first versus second order improvements, which involve the overemphasis on new services and forgetting the daily business need to be worked against. Also, the bottleneck of manpower needs to be structured either by additional workforce or by clearly allocating the amount of additional service besides day-to-day activities by the organization.

Oliva et al (2003) underline these focus topics. Especially important for them is the creation of a new business unit with their own sales force and service technicians as well as IT support and processes. The difficulty, that building such an organization and investing in know-how, human resources, IT- and process-infrastructure, etc. first costs a lot of money without realizing revenues right away as well as the time factor, which is needed to build up knowledge and smoothly run processes, need to be overcome by creating internal and external credibility gradually through continuously improving the generated revenues, building customer networks and continuing to fine-tune the organization stepwise.

The third phase of the implementation, according to Oliva et al (2003) is the expansion of the offering for the installed base service as soon as the second phase has been implemented. Two major transitions take place in this phase. On the one hand a move towards relationship-based services, moving into a closer relationship with the customer, etc. and on the other hand a move towards process-centered services, away from whether a product at a customer site works or not towards value creation for the customer through the individualized and efficient use of all products in the customer's processes, takes place. In order to realize relationship-based services, the manufacturing company needs to move towards assuming the operating risk of the equipment. Good examples of how this can be realized, according to Cohen et al (2006), are the power-by-the-hour concept, for instance used for aircraft engines, as well as performance based service contracts. Oliva et al (2003) continues to state that the risk of taking over the responsibility for the equipment in this phase should be compensated through economies of scale and the expansion of the company's network as well as higher efficiency through learning curve effects. In order to realize process-centered services, the manufacturing company needs to move into fields such as consulting, make changes to or even initiate a new distribution network as well as include other manufacturers in the processes. Mathieu (2001b) adds to that the possibility of cooperating with selected competitors to share the risk, pool resources and knowledge and thus strengthen one's position in the market, while offering outstanding service to the customer.

In the fourth and final phase, Oliva et al (2003) suggest becoming pure service organizations. This means that the manufacturing company would fully be responsible for their customers' processes including taking over entire organizational parts, for instance the MRO. This step, however, should only be implemented when all other steps have fully and successfully been established.

In summary, this concept to realize servitization and an extended service business for manufacturing companies is broken down into three basic steps by Gebauer (2007). In a first phase the manufacturer needs to offer a superior customer service for their products, e.g. information, high quality catalogs, quick response time to questions asked, etc. In a second phase the company needs to move on to providing product-related services for their respective installed base, e.g. MRO, before in the last step the manufacturer can move on to additionally offering customer support services or even taking responsibility for the proper functioning of the customers' equipment, thus offering solutions to the customer rather than products and/or services (Gebauer et al, 2016) , e.g. the power-by-the-hour model as introduced by Rolls-Royce (Cohen et al, 2006; Jovanovic et al, 2016)

2.2.5 Spare parts management in servitization

As seen in the previous chapters, for manufacturing organizations there are different PSS-approaches to focus on and there are structured ways for these organizations to servitize. A full picture of service offerings and their implications that may be considered when looking at servitization and PSS is given by Gebauer et al (2012). Please see **Figure 14** for a detailed overview.

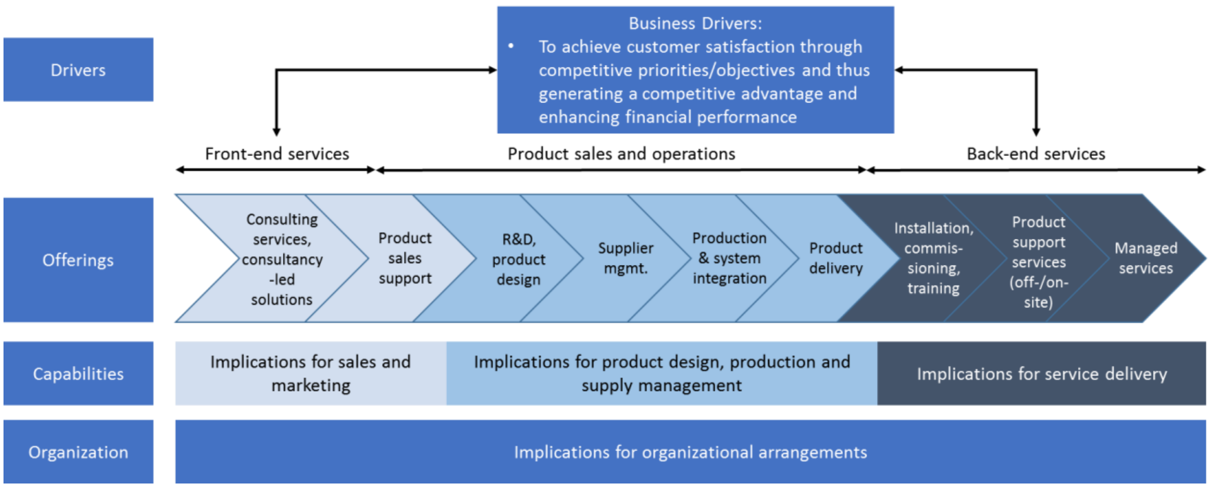


Figure 14: An integrated framework of service development in manufacturing (Own adapted figure based on Gebauer et al, 2012)

According to Gebauer et al (2012), a shift away from the product-focus with proper R&D, design, production, delivery, etc. towards value-added services that support the product in order to create a solution for the customer comes through additional elements in the front- and in the back-end in their framework. In the front-end, the focus is on additional services that deal with marketing and sales, e.g. consulting and sales support. In the back-end, the focus is on service delivery. According to Gebauer, Krempl, Fleisch and Friedli (2008) as well as Gebauer et al (2012) this can be achieved through trainings and the installation of a product as well as product support services such as spare parts management and MRO.

Avlonitis et al (2014) add that the offerings mentioned to add onto a product can also be divided into two categories with different strategic mind-sets. On the one hand, services such as consulting, but also monitoring services and preventive maintenance as well as financing, etc. are generally valuable when the business strategy, i.e. servitization, aims primarily, but not exclusively, at creating new business opportunities and new customer relationships. On the other hand, services such as trainings, helpdesks, the installation of products and units as well as corrective maintenance aim primarily, but not exclusively, at a business strategy, i.e. servitization approach, of protecting and strengthening relationships with current customers and thus building higher barriers for the competition.

Spare parts are essential for both types of strategies as they are needed for corrective as well as preventive maintenance (Avlonitis et al, 2014). In addition, spare parts are also of particular importance, as they form the backbone for all three of Tukker's (2004) PSS, i.e. product orientation, use orientation and result orientation to keep the units in operation. For product oriented PSS, spare parts are sold as add-ons to enable the customers to keep their units operational. In use oriented PSS, e.g. equipment leasing, and result oriented PSS, e.g. power-by-the-hour models, spare parts are necessary for the manufacturer to keep the units in operation.

As displayed in Gebauer et al's (2012) framework, eventually it is a profit-oriented organization's ultimate goal and driver to create a competitive advantage and thus financial benefits. This is achieved through customer satisfaction, which again can be achieved through the operational competitive priorities/objectives displayed in **Figure 10**. Spare parts management and logistics, due to their important role in the concept of servitization and the advantages they can generate for companies will be focused on in the next chapter.

2.3 Spare parts logistics management

2.3.1 Introduction to spare parts logistics management

According to a large number of authors (e.g. Armstrong & Associates, Inc., 2010; Cheng, Barton and Prabhu, 2010; Klug, 2010; Gleißner and Möller, 2011; Wagner, Jönke and Eisingerich, 2012; Politis et al, 2014), spare parts logistics may have an outstanding impact on creating a competitive advantage through quick and high quality processes while keeping costs as low as possible for any (manufacturing) company trying to servitize. Especially in markets and industries with high value products such as automotive, industrial and technology, spare parts logistics and its management play a highly important role with regards to service and thus differentiation from the competition. Additionally it functions as a major generator for margins as approximately 70% of revenues in service are generated through spare parts logistics (Impuls, 2003 as cited in Dombrowski and Schulze, 2008).

DIN-norm 24420 defines spare parts (or service parts as they are also often referred to) as "parts, groups of parts or entire products that are meant to replace broken, torn or missing parts, groups of parts or entire products"[2] (as cited in Fortmann and Kallweit, 2000, p. 122; Schake, 2000, p. 55; Schuh, Stich and Wienholdt, 2013, p. 167). Dealing with spare parts, spare parts logistics management is a subdivision of logistics management and handles the sourcing and purchasing, warehousing as well as delivering of the right spare parts in the right quality and quantity at the right time and at the lowest possible cost to the right location (Schake, 2000; Gleißner et al, 2011; Schuh et al, 2013).

Gleißner et al (2011) identify five competitive objectives that need to be considered when looking at efficient spare parts logistics management. Namely, those five elements are quality, flexibility, availability as well as cost and delivery service. These five competitive priorities closely match the general core objectives of general operations management as identified by numerous authors (e.g. Santos, 2000; Slack et al, 2009; Hayes et al, 1984, Fine et al, 1985 and Ward et al, 1998 as cited in Szász et al, 2013; Avlonitis et al, 2014; Slack et al, 2014). Gleißner et al (2011). Dependability of a service and the delivery on a promised date thereby is closely linked to the availability of parts, tools and service technicians. Furthermore, it is notice-worthy to state that delivery service is of particular importance in spare parts logistics as time plays a very significant role in any service operation dealing with spare parts as stated by numerous authors, e.g. Stalk Jr. (1988) and Moore (1999).

Also, it is important to notice that spare parts logistics differs drastically from logistics for finished goods. Demands fluctuate much more, are usually unpredictable and when needed, then within a very short time frame (SCDigest Editorial Staff, 2007; Gleißner et al, 2011). Other factors such as different lifecycles (Klug, 2010) and the portfolio size (Pfohl and Trumpheller, 2005) need to also be considered when looking at high quality spare parts logistics management.

Pfohl et al (2005) systematically explain the special logistical role of spare parts and service in the aviation industry. They state that the MRO is essential for staying profitable as airplanes can only earn money for the company when they fly. Airplanes therefore have to be working in perfect condition at all times, not at last to secure safe and comfortable travels for the passengers and the crew. Airlines and third-party service providers try to accommodate these requirements by building logistics networks, stock all critical parts for their portfolio of airplanes and make them accessible in their relevant locations at all times. In the end that accounts for an estimated 20-30 billion US-dollars in aviation spare parts on stock worldwide. The key points

[2] Translated from German: "Teile, Gruppen oder vollständige Erzeugnisse, die dazu bestimmt sind, beschädigte, verschlissene oder fehlende Teile, Gruppen oder Erzeugnisse zu ersetzen" (as cited in Fortmann and Kallweit, 2000, p. 122; Schake, 2000, p. 55; Schuh, Stich and Wienholdt, 2013, p. 167).

why airlines or the third-party service providers still opt to stock these amounts of parts are clear, however: First of all, the costs of an airplane on the ground, which is unable to fly due to missing parts, outweigh the storage costs. Second of all, the loss of reputation that goes along with cancelled or delayed flights due to missing spare parts can cause serious damage for the airline. Airplanes that have crashed or had an accident due to insufficient parts or bad maintenance are obviously even more serious. As a third point, the authors state that by having spare parts logistics and the after-sales services, i.e. the MRO, organized this way results in longer life-time of the airplanes, which in the end again means more profitability.

This being said does not mean that airlines and third-party service providers accept the fact that spare parts logistics is expensive. Much rather the opposite is the case. While spare parts logistics and after-sales services in this industry tend to become more complex and costly, for them while accepting the cost level to a certain degree it is equally important, not to say essential, to improve this business constantly in order to maintain the competitive advantage or even to just stay competitive compared to other companies (Pfohl et al, 2005). While for customers, high value for a competitive price is necessary, CEOs and managing executives, according to Goddard and Pierre (2016) do not have a choice between cost and value in today's business anymore. Both cost leadership as well as a differentiated offering, which (temporarily) gives a competitive value advantage, can be overcome quicker and quicker by competitors. For CEOs and managing executives, it is therefore essential to focus on both strategies simultaneously and balance them flexibly and according to the pressures occurring in the market to remain competitive and profitable at all times.

The critical impact that spares logistics can have on industries that heavily rely on their after-sales can also be seen in an article in Focus Online (2013) concerning the German car manufacturer BMW. The article outlines the negative impact on customer satisfaction and margins due to software problems that occurred in their repair shops throughout Germany. Customers had to wait multiple weeks for their ordered spare parts, the shops were unable to give reliable information on when the parts would be available again and customers had long times without their car or just a rental car. This quickly resulted in noticeable customer dissatisfaction and lost revenues for BMW.

Whereas for most companies spare parts logistics is an important, yet not the most important source for profit, Gudehus in 1999 as cited in Fortmann et al (2000) as well as Enarsson (2006) noticed that in certain industries such as the elevator industry, spare parts logistics play an even more crucial role than in the aviation or automobile industry and for certain companies may even be of higher importance than the products themselves. The authors outline and are supported in their argument by Baader, Montanus and Sfat (2006), that whereas usually spare parts logistics is often seen as a needed after-sales function that requires high efforts and costs a lot of money by employing capital in stock in order to support the production base, in these industries spare parts logistics are far more than that. Here, only very low margins can be generated through newly installed units and a major portion of the margins generated comes from the after-sales market and especially the spare parts and service logistics. According to Wagner et al (2012) these can be as high as 50% of the total. Companies in industries with high numbers of installed equipment, such as machines, industrial printers, construction equipment, agricultural units, elevators, etc. realize this need for a higher focus on servitization with emphasis on spare parts logistics management concepts and optimization more and more (Baines et al, 2009).

To conclude, the increased attention and need for spare parts logistics, their important role for businesses in today's economy (e.g. Armstrong & Associates, Inc., 2010; Cheng et al, 2010; Klug, 2010; Gleißner et al, 2011; Wagner et al, 2012) and especially in manufacturing companies' aims to servitize (e.g. Gebauer et al, 2012) is obvious. In some industries, spare parts logistics can even be a major source for a company's revenues and margins (Gudehus, 1999 as cited in Fortmann et al, 2000; Baader et al, 2006; Wagner et al, 2012) and therefore should constantly be optimized (Pfohl et al, 2005). In order to satisfy the customer and remain a competitive player in the market, a focus on spare parts logistics management in the concept of servitization boosts a lot of potential for companies and should therefore be focussed on.

2.3.2 The importance of downtime reduction in service business

As mentioned previously, there are five competitive objectives to consider when aiming to optimize spare parts logistics processes in order to satisfy the customer, according to Gleißner et al (2011). Companies and providers active in after-sales services, according to the authors, need to consider quality, cost, availability, i.e. dependability, flexibility, and delivery service, i.e. speed/timeliness. Whilst all of these factors need to be considered as they may have interdependencies and cannot be addressed simultaneously without creating trade-offs, as suggested in the sand cone model (Ferdows et al, 1990; Slack et al, 2014) or the alternative focus approach suggested by Slack et al (2014), when optimizing in order to create improved spare parts logistics to generate a competitive advantage and customer satisfaction, especially timeliness/speed plays a significant role in spare parts logistics (e.g. Stalk Jr., 1988; Moore, 1999) as previously mentioned. This is displayed in **Figure 15**.

Figure 15: Highlighting the importance of speed in creating customer satisfaction in service business (Own adapted figure based on Slack et al, 2014)

Whereas the goal of any company owning (high value) end-items needed to offer a product and/or a service to the customer is to minimize downtime (or even fully eliminate it) and simultaneously maximize uptime through concepts such as preventive maintenance and total quality management (TQM) with the result of total productive maintenance (TPM), etc. (Rizzo, 2008), in reality sudden break-downs of machinery cannot fully be eliminated and therefore especially quick, efficient and effective corrective maintenance is needed in these cases (Lofsten, 1999).

As seen in the examples given by Pfohl et al (2005) and Focus Online (2013), it is confirmed that when an end-item breaks down unexpectedly, the downtime of that device, regardless of it being an airplane, a machine, a car, etc. causes extremely high costs and usually dissatisfaction for the customer with all its consequences, e.g. loss of reputation, etc. The break-down of a computer system, according to Öner (2010), for example, can create downtime costs of approximately 100,000 to 1,000,000 USD per hour for larger e-commerce companies. This is supported by Cohen, Zheng and Wang (1999), who state that one hour of downtime of an electronic tester in the semiconductor industry costs up to about 50,000 USD. These downtime costs as stated by Öner (2010), may be the result of losses in revenues and margins, idle times of employees as well as potential fines. He adds that in general and on average the downtime of a capital good accounts for approximately 48% of the total costs of ownership. Together with the maintenance (approximately 27%), the after-sales service costs of a capital good account for 75% of the total costs. Acquisition costs usually average at around 23%, while operating costs account for the last 2%. Please refer to **Figure 16** for an overview of Öner's (2010) data.

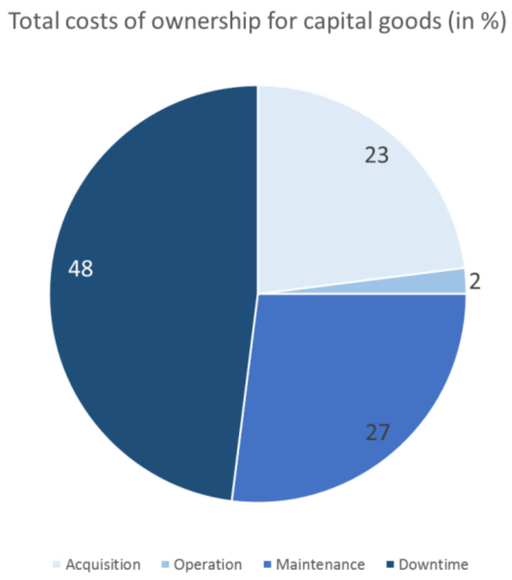


Figure 16: Total cost of ownership for capital goods (Own figure based on Öner, 2010)

According to Öner (2010), manufacturing companies nowadays increasingly feel the pressure to especially reduce downtime costs. Customers in today's business world have recognized that they must look at an acceptable total cost of ownership rather than a low purchasing price when acquiring an item. The lower the downtime costs (maybe even in combination with reduced maintenance costs) for a machine, e.g. airplane, industrial machinery, elevator, etc. are, the better are the chances for a manufacturing company to sell it to the customer. Another reason why downtime reduction plays a vital role for equipment producers is the rising trend towards performance-based after-sales service contracts as well as power-by-the-hour contracts, where, as explained previously, the servitized manufacturer assumes operating responsibility for the equipment and is paid for the equipment's performance (Cohen et al, 2006; Jin and Tian, 2012). In both cases, the manufacturer is directly affected by the machine's downtime and thus will try to avoid it as much as possible (Öner, 2010, Jin et al, 2012).

These facts in combination with the general trend towards servitization show the need for continuous improvements in the field of spare parts logistics. On the one hand, these improvements are required to satisfy the customer by minimizing downtime and thus costs. On the other hand, also the costs and efforts for the after-sales service provider can be drastically reduced through optimizations in this field. Overall, improvements in this sector have the potential to create win-win situations, as the customer will be satisfied with the equipment facing minimal downtimes and the service provider will be satisfied by the additional margins created due to diversification through outstanding after-sales and spare parts logistics services.

2.3.3 Downtime reduction in corrective maintenance by affecting response time

2.3.3.1 Service response time

Once an end-item breaks down, it is essential to quickly repair it in order to avoid downtime with all its consequences (Lofsten, 1999). This, in this case, is done through corrective maintenance usually provided by either the original equipment manufacturers' (OEMs) after-sales service departments, if servitized, or third-party service providers.

A typical simplified corrective maintenance process is provided by Prakken (2009) as cited in Alvarez (2013) (see **Figure 17**).

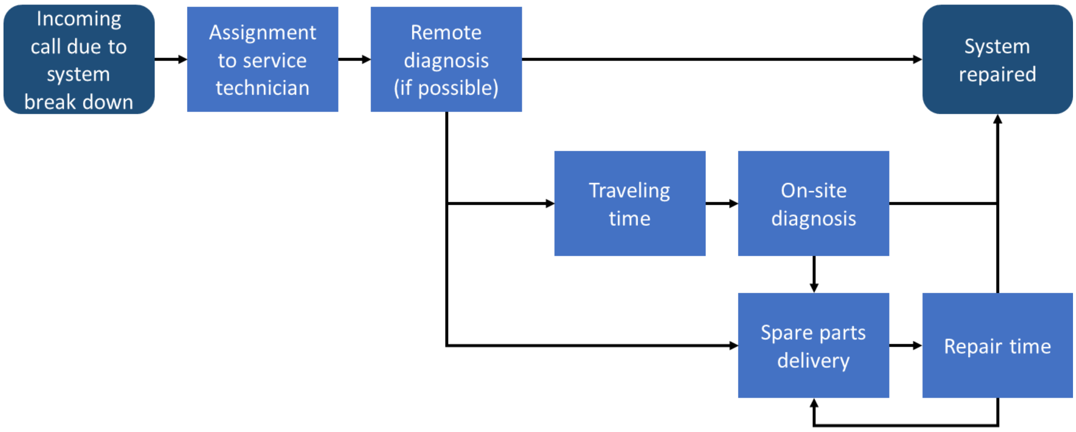


Figure 17: Typical steps in a corrective maintenance process (Own figure based on Prakken, 2009 as cited in Alvarez, 2013)

In this typical process, according to Quintana and Ortiz (2002) as well as Alvarez (2013), as soon as the system, e.g. elevator, machine or car, etc. breaks down, the contracted after-sales service provider (third-party or OEM) will be called for repair services. The service provider then assigns a service technician to that break-down as soon as possible. The assigned service technician or the back office contacts the customer regarding the problem and tries to give remote help, if possible. If not possible, the service technician will drive to site and diagnoses the problem and identifies the spare part(s) needed. In a best-case scenario, in his/her service car he/she has the required spare part(s) to overcome the problem right away. In other cases, especially for expensive parts or parts that are not frequently needed in maintenance and repair, the service technician after identification of the part(s) to be repaired, orders it/those through an ordering process at the warehouse or the back office. If even at the warehouse the part(s) is/are not available, the purchasing department orders it/them. As soon as the part(s) is/are available, the service technician returns to site, disassembles the malfunctioning part(s), exchanges it/them and repairs the broken down unit so that it functions again. If after repair, the end-item still does not work, further problem diagnoses have to be initiated and the corrective maintenance process repeats itself until the problem is finally fixed.

Obviously, with respect to the financial and reputational consequences resulting from the previously mentioned downtime effects of a system, the main goal of the after-sales service provider and its mechanics or service technicians must be to respond to break-downs as quickly as possible in order to generate a high or maximum availability of the end-item and its utilization by the customer (Alvarez, 2013).

As stated by different authors (e.g. Schultz, 2004; Jin et al, 2012; Ståhl, Gabrielson, Andersson and Jönsson, 2012; Alvarez, 2013; Mirzahosseinian and Piplani, 2013) the availability of an end-item or system is affected by two main factors: the mean time between failures (MTBF), expressing the average time period between consecutive failures of an end-item or its reliability, and the mean time to repair (MTTR), expressing the average time it takes to repair the end-item after a break-down. This can be expressed in the following formula:

$$Availability = \frac{MTBF}{MTBF + MTTR}$$

Alvarez (2013) adds a third factor, namely the mean logistics delay time (MLDT), which expresses the actual average waiting time for all needed resources to be available to conduct the corrective maintenance, e.g. spare parts, service technicians, tools, etc. Her formula to express the availability of an end-item then changes slightly and looks as follows:

$$Availability = \frac{MTBF}{MTBF + MTTR + MLDT}$$

Most of the other previously named authors include the MLDT in the MTTR and do not look at it separately. Overall, however, both Alvarez' (2013) and the other author's formulas show that the availability of an end-item can be influenced by both a high MTBF and/or a low MTTR and MLDT. The higher the MTBF and the lower the MTTR and MLDT, the better the availability of the end-item.

According to Verrijdt (1997), in order to comply with the requirements of high availability for end-items, there are numerous performance measures in practice that support the service surveillance internally at the OEM or third-party service provider on the one hand as well as within their respective service network on the other hand. Five commonly used service performance measures, according to Cohen and Lee (1990) as cited in Verrijdt (1997) are the part unit fill rate, the part dollar fill rate and the order fill rate looking at internal processes such as optimized on-hand inventory or replenishment methods to serve customer demands efficiently as well as repair order completion rate and customer delay time respective (service) response time to the customer for holistic service demand fulfillment measures.

The service response time, according to Cohen, Zheng and Agrawal (1997), looks at the entire corrective maintenance process from a customer demand for service until the end-item is available again. During this process, it is influenced by factors such as the diagnosis time, the logistics delay to receive missing parts and the time to repair the unit. This is displayed in **Figure 18** (Cohen et al, 1997).

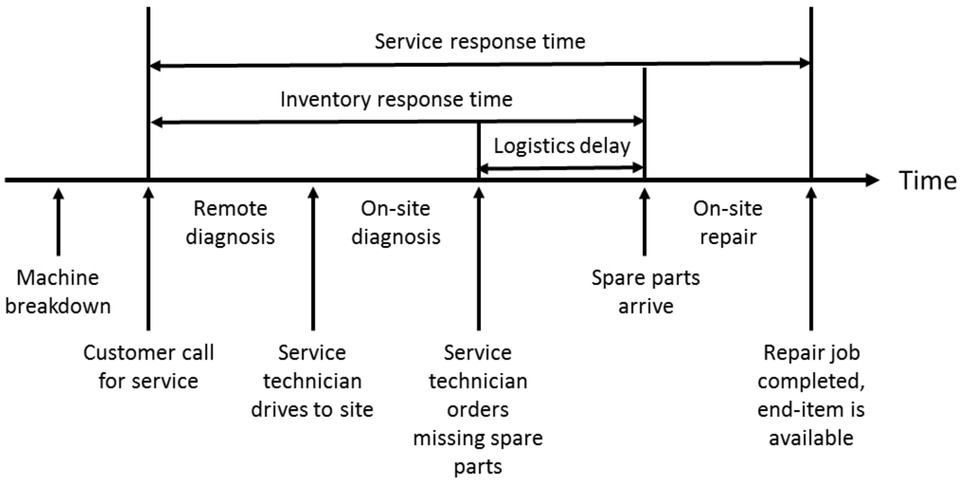


Figure 18: Service response time (Own figure based on Cohen et al, 1997)

Deviating slightly from Cohen et al's (1997) view on the factors affecting the response time and thus the availability of an end-item, Alvarez (2013) suggests that the logistics delay time is not only affected by waiting for unavailable parts, but also the allocation of tools and service technicians as well as the differentiated service contracts and service response times agreed upon between the OEM or third-party service provider and the customer.

Due to the necessity to focus on certain aspects in the course of this thesis, and given the importance and relevance of quick response times in corrective maintenance for after-sales service and spare parts logistics with the potential levers they hold for service providers, the focus of the next chapters will therefore be a detailed review of the influence factors of MTTR and MLDT. MTBF, which focusses on the reliability of machines and which can be influenced through measures such as preventive maintenance (e.g. Cavalcante and de Almeida, 2007) or new technological developments such as critical function replication in computer system sub components (e.g. Birman and Glade, 1995), etc. for instance, will not be covered in detail in this thesis.

2.3.3.2 Influences on MTTR and MLDT (service response time)

A large amount of authors (e.g. van Gigch, 1965; Quintana et al, 2002; Pfohl, 2004; Schultz, 2004; Köpfli and Amstutz, 2008; Cheng et al, 2010; de Souza, Tan, Othman and Garg, 2011; Jin et al, 2012; Alvarez, 2013; Mirzahosseinian et al, 2013; Tiemessen and van Houtum, 2013; van der Heijden, Alvarez and Schutten, 2013) have stated a variety of different factors that influence (spare parts) logistics and throughput time in service and thus need to be considered when looking at service response time improvement for downtime reduction and end-item availability optimization.

Pfohl (2004) for instance explains that there are four variables that can be influenced in order to improve logistics management (and therefore spare parts logistics). First and foremost, there is the definition of the task, i.e. more logistics efficiency. Depending on that, the three variables that can also be influenced, namely employees, technologies and organization, can be dealt with. If one of the variables is worked on, usually it also has an effect on one or all of the other variables as well. This needs to be taken into consideration when planning and implementing changes that deal with logistics management.

Furthermore, however, there are also other factors that cannot be influenced, but still have to be considered. On the one hand there are variables within the organization that cannot easily be influenced such as the size of the company, company policies and politics as well as the available production sites. On the other hand there are variables outside the company that also have potential influence on the logistics management such as demands, technological and economic developments as well as other specific issues within an industry, transport infrastructure, political and legal boundaries, etc. (Pfohl, 2004).

Besides these rather high-level factors, a lot of authors (e.g. Huiskonen, 2001; Schultz, 2004; Kranenburg and van Houtum, 2007; Bacchetti and Saccani, 2012; Jin et al, 2012; Alvarez, 2013; Mirzahosseinian et al, 2013; Tiemessen et al, 2013) feel like a major influence factor for response time is inventory management and the supporting network of warehouses and supply facilities as well as spare parts classification, oftentimes in combination with multi-echelon supply chain and network optimization (e.g. Cohen, et al, 1999; Caggiano, Jackson, Muckstadt and Rappold, 2007; Candas and Kutanoglu, 2007). Jin et al (2012) further include process factors such as the diagnostics time and delivery time of spare parts as major influences, Köpfli et al (2008) add the importance of quick identification, van Gigch (1965) looks at repair time and man-hour reduction through optimized maintenance activities, Cheng et al (2010) put their research efforts on procurement and tool management, van der Heijden et al (2013) focus on transport and repair time issues and Quintana et al (2002) concentrate on the optimization of mechanics scheduling and assigning to improve response times. Alvarez (2013) besides the inventory further states the importance of optimized allocation and availability of service technicians and tools. She further states that a major point to consider for customers is the individual service contract. If a long response time was agreed upon with the manufacturer or third-party service provider due to financial reasons, etc. obviously the response time will be according to that contract and unlikely much quicker. Further literature on affecting service response time includes repairs optimization (e.g. Sleptchenko, van der Heijden and van Harten, 2003), customization (e.g. Jalil, 2011), information logistics including forecasting (e.g. Romeijnders, Teunter and van Jaarsveld, 2012), radio frequency identification (RFID) technology (e.g. Dittrich, 2008), installed base information (e.g. Jalil, Zuidwijk, Fleischmann and van Nunen, 2011; Dekker, Pinçe, Zuidwijk and Jalil, 2013), final order concepts (e.g. van Kooten and Tan, 2009), performance optimization in supply chain management (SCM) (e.g. Kleijnen and Smits, 2003; Gunasekaran, Patel and McGaughey, 2004) as well as key performance indicator (KPI) management (e.g. Muchiri, Pintelon, Martin and de Meyer, 2010) and scheduling (e.g. Haugen and Hill, 1999), etc.

Also, in the context of reducing response time, obviously preventive maintenance (e.g. Samet, Chelbi and ben Hmida, 2010) as well as similar concepts such as condition based monitoring (e.g. Brax et al, 2009; Golmakani and Fattahipour, 2011) are largely covered in previously conducted research.

In accordance with Pfohl (2004) as well as with Thomas' (1974, p. 90) statement as cited in Bickel (2003, p. 1) "You cannot meddle with one part of a complex system from the outside without the almost certain risk of setting off disastrous events that you hadn't counted on in other, remote parts. If you want to fix something you are first obliged to understand ... the whole system...", a holistic view on factors affecting service response time in corrective maintenance is needed for the purpose of this thesis to structure the available research and to identify a gap for further work.

A lot of current literature already deals with the implications of complexity and the interdependency of factors to be considered in supply chains (e.g. Choi, Dooley and Rungtusanatham, 2001; Huiskonen, 2001; Choi and Krause, 2006). De Souza et al in 2011 in their work, however, specifically suggest a framework of six influence factor categories that need to be looked at in order to properly manage spare parts logistics and reduce response times. These six categories can be found in **Table 1** and will be used as a guideline for a more detailed and specific literature review in this context.

Influence factors	Examples
1) Customer service objectives and goals	• Efficiency improvement • Customer satisfaction • Response time reduction
2) Supply chain network	• Network configuration
3) Enablers	• Technology • Measurements • Air and sea connectivity
4) Processes	• Transportation • Warehousing • Reverse logistics • Order processing • Distribution
5) People	• Skill sets • Knowledge • Training
6) Others	• Infrastructure • Government regulations • Incentives

Table 1: Factors influencing service response time in spare parts logistics (Own table based on de Souza et al, 2011)

According to de Souza et al (2011), Factor 1 (customer service objectives and goals) deals with the aim to create value for the customer and thus strengthen one's own competitive position. This, as identified in this literature review and thus contributing to knowledge, can be achieved through an operation that supports servitization with a focus on after-sales services such as spare parts logistics management optimization, for instance through reducing response times in such a way that a win-win situation between the customer and the OEM or third-party service provider can be generated. Factor 2 (supply chain network), according to the authors, deals with the optimal service network creation including stock locations and inventory to fulfill the requirements of Factor 1. Factor 3 (enablers) deals with the necessary technological inputs needed, Factor 4 (processes) looks at all the necessary processes and Factor 5 (people) deals with the skill and knowledge level as well as training of the service employees in order to satisfy Factor 1. Factor 6 (others) includes all the factors that cannot easily be influenced, yet have an influence on the response time themselves.

The research conducted previously in the area of spare parts logistics optimization will therefore be covered in more detail in the next chapters and will be classified into one of the six previously mentioned groups of influence factors defined by de Souza et al (2011) in order to identify, where exactly more research is needed in order to optimize corrective maintenance with respect to response time and equipment downtime minimization and thus to contribute to knowledge and business practice with the research applied in this thesis.

2.3.3.3 Customer service objectives and goals

As stated by numerous already mentioned authors (e.g. Porter, 1985; Pfohl, 2004; de Souza et al, 2011), the main goal for a company is to create value for its customers and thus satisfaction. This again, according to de Souza et al (2011), can be seen as the starting point for operational excellence in service management (Factor 1). It has been outlined in the literature review on servitization (**Chapter 2.2**), which role spare parts logistics plays in this context and how it can be used to reach the overarching goals of value creation for customers.

2.3.3.4 Supply chain network

Especially Factor 2 in de Souza et al's (2011) model, which deals with the topic of inventory optimization in combination with multi-echelon supply chain and network optimization has been researched extensively and dates back to the mathematical multi-echelon technique for recoverable item control (METRIC) model of Sherbrooke (1968). This model is widely accepted to be the first to include all major issues when determining optimal stock levels for repairable items within a network of warehouses and stock locations in order to minimize downtime of the installed base products of a given company (Verrijdt, 1997).

A typical multi-echelon structure for manufacturing companies of (high-value) end-items has been presented by Verrijdt (1997) in **Figure 19**.

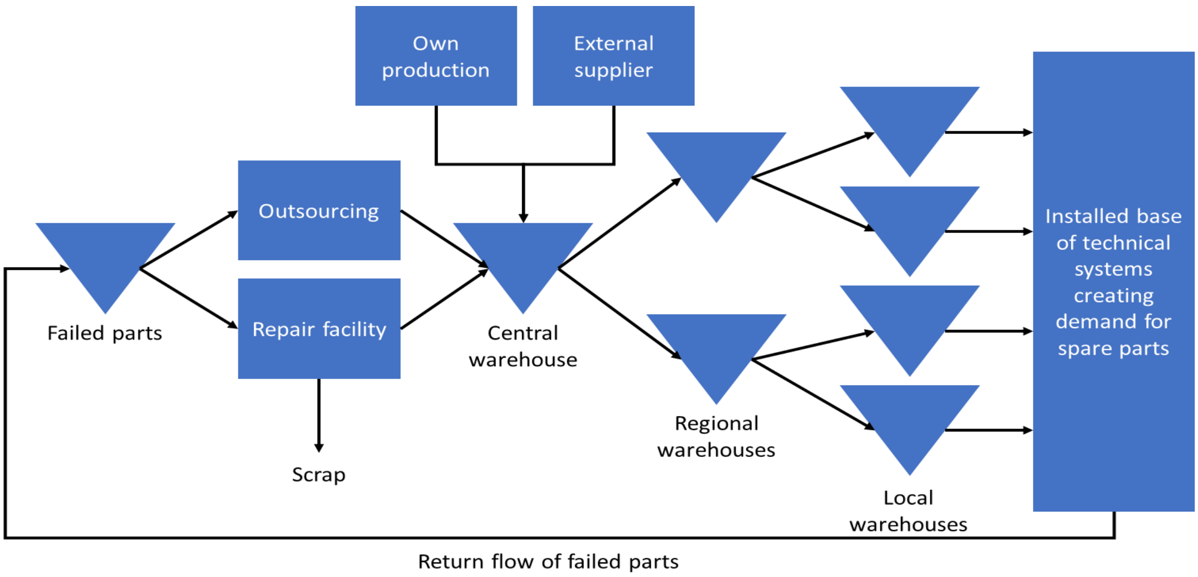


Figure 19: Typical multi-echelon network (Own figure based on Verrijdt, 1997)

Sherbrooke himself in 1971 further developed his model by recognizing that only end-items that are critical to the operation of a system have an effect on a potential downtime. Shortages of and/or missing components and parts that make up the end-item only have an indirect effect, because they delay the repair of the end-item. If a fully functional end-item were to be stored, however, the downtime of the installed base unit would not be affected. During the course of time, multiple authors further extended and optimized the model or pointed it in a different direction. Muckstadt (1973) in his MOD-METRIC model for instance modified the METRIC model in order to allow for an inclusion of a parts hierarchy in order to better control the multi-item, multi-echelon and multi-indenture inventories and to determine the best possible positioning of end-items in the network of stock locations and warehouses in order to quickly supply a missing unit (Verrijdt, 1997). In 1980, Muckstadt and Thomas further expanded the model in order to be able to give a control method for consumable service parts inventory, which cannot be repaired and reused. To improve the calculation model even further, Sherbrooke (1986) describes improved assumptions on the distribution of order backlogs to create better approximations for the mathematical formulas (VARI-METRIC).

In recent years a large variety of further add-ons to and/or changes based on the METRIC model and its follow-ups have been researched. Scudder (1984) for instance looks at priority scheduling, Caggiano et al (2007) as well as Candas et al (2007) include the effects of time-based service-level agreements in their mathematical formulas and Wong, Kranenburg, van Houtum and Cattryse (2007) researched the effects of aggregate mean waiting times in warehouses, etc. A combination of inventory optimization and throughput time reduction, for instance, has only recently been given attention to by van der Heijden et al (2013). Other mathematical optimization approaches to inventory and network designs have also gained a large variety of research in recent years. Wong, van Houtum, Cattrysse and van Oudheusden (2005) for instance look at the effects of lateral transshipments and waiting times, Koçağa and Şen (2007) differentiate between immediate demand and demand lead times in inventory management, Karsten, Slikker and van Houtum (2012) look at the effects of inventory pooling and Piplani and Saraswat (2012) focus on the mathematical design of reverse logistics networks, etc.

Another major subsequent contribution to show the success of optimized inventory levels of service parts and network usage of stock locations and warehouses under certain service fulfilment requirements was developed by Cohen, Kamesam, Kleindorfer, Lee and Tekerian (1990) through research at IBM. The changed business environment IBM faced at that time led them to rethink their strategy in terms of their inventory control system and network allocation of parts. The new needs for IBM included a high level of strategic flexibility to fulfill different service needs in different markets as well as an improved inventory level and inventory utilization to reduce costs in their large multi-echelon service structure with a manufacturing centre, national and regional warehouses, sub warehouses, local stations and outside locations as well as their installed base. By developing and implementing the so-called Optimizer software, which included practical issues such as emergency deliveries, stock pooling, etc. in their mathematical formulas and algorithms, IBM was able to improve their spare parts logistics processes and structures in a way that made a much better use of the approximately 200,000 article numbers and the respective data. Through these improvements, they were able to reduce inventory and operating costs through the system's flexibility as well as a more accurate forecasting and planning and they were able to improve the service level to the customer.

Despite their successes, the problem with all of these mathematical approaches, however, is the limitations they usually have. Oftentimes the models are specifically designed for a certain company with certain issues. Other times the models are theory-based and do not include all the necessary variables in order to create a holistic calculation model that is practically usable in the industry. Usually, in these cases, the models can only focus on certain aspects in certain circumstances and need to neglect others in order to be put into a manageable amount of logical formulas, which then again are hard to adapt to by the industry or companies, where factors vary from the suggestions in theoretical research or from the examples of another company. Further research in this area seems necessary, thus providing a potential gap in literature.

Huiskonen (2001), therefore, instead of using a mathematical approach, for example focusses his research to optimize the inventory and network structure as well as to improve the control of these issues on certain characteristics of spare parts and the differentiation of them. According to the author, the widely used tools such as ABC-analysis, re-order point and economic order quantity definitions, etc. are not sophisticated enough to be used in demanding spare parts systems with multiple echelons, etc. For him, it is clear that the high level of complexity in most spare parts scenarios is affected by interdependent factors that all need to be looked at when optimizing the inventory and network structures in spare parts logistics (see **Figure 20**).

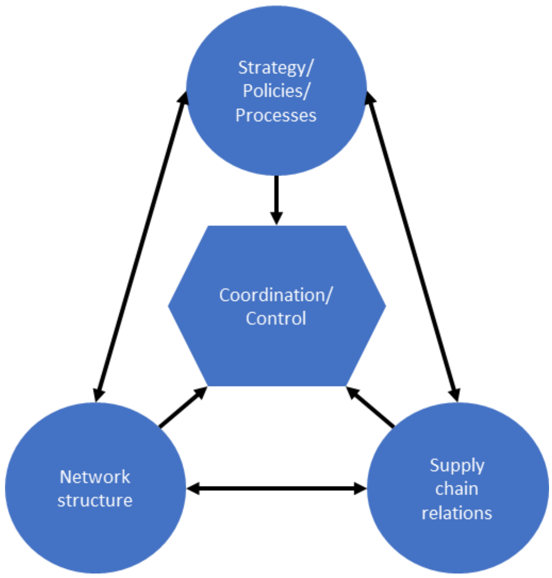


Figure 20: The constituting elements of a logistics system design (Own figure based on Huiskonen, 2001)

The field of strategy, policies and processes needs to be looked at when deciding which level of service needs to be offered to the customer. A contractual differentiation should be made between customers that require service within a not too critical amount of time (e.g. in a scenario where one of multiple printers in an office building breaks down, but the work rhythm of the employees is not affected), or immediately respectively as soon as possible for instance (e.g. in a scenario of an elevator for beds in a hospital, where a break-down has an immediate effect on the work rhythm of the employees). This needs to be supported by the respective processes and structures within the organization. The network structure is needed to decide where and how many stocks are created to support the spare parts organization. The supply chain relations deal with the amount of integration with suppliers and customers and the co-operation between the parties. The field of coordination and control is affected by the three previously mentioned aspects. Here the management of all these issues is dealt with, the performance is controlled and information is handled (Huiskonen, 2001).

In order to react to those factors, the differentiation of spare parts categories Huiskonen (2001) therefore looks at in order to create an optimized spare parts network with the right amount of inventory are criticality, specificity, demand patterns and the value of the parts. The criticality in this case deals with the importance of a part for the operation of the end-item. A differentiation between parts can be made by looking at parts that immediately cause the system to stop working, parts that can be reacted to by temporary arrangements until the spare part has been supplied, and parts that are not critical and can be repaired during the next maintenance. The specificity, according to Huiskonen's (2001) model differentiates the parts into standard parts that are available through numerous suppliers and on the other hands customized parts that are only made at limited manufacturers or that are only made for certain customers. The demand pattern can also be used as an indicator for a spare parts service supplier on how much and where to stock certain items. The value of a part is also important, yet usually already used by most inventory holding companies through ABC-analyses, etc.

Other authors such as Cohen, Cull, Lee and Willen (2000) also focus their approach on inventory and/or network modelling on practical circumstances such as criticality to the customer, etc. rather than a mathematical model. Chang and Lu (1994), for example identify six problems that affect the inventory level (e.g. wrong orders made by personnel, lack of experience, lack of regular scrapping, etc.) and Kranenburg et al (2007) look at the effects of commonality in end-items under maintenance for spare parts supply.

Overall it can be seen, that both mathematical and practical approaches range greatly and have been researched to a very large extent already, even though potential further research needs could also be identified in this review, i.e. the need for further research on limitations regarding mathematical models in supply chain network optimization.

2.3.3.5 Enablers

According to de Souza et al (2011), for Factor 3, technology is a first major contributor to successful after-sales service business. Especially enterprise resource planning (ERP) software, such as the well-known SAP-system, are critical to manufacturers dealing with spare parts, as they support the management among others in tasks such as inventory tracking and analysis in the warehouse or in the multi-echelon network, monitoring of repair operations and the generation of reports to reflect KPI, etc. Furthermore, they can link all departments of a company together and are even open to interfaces to other systems (Singer, 2002). Patton and Feldman (1997) as cited in de Souza et al (2011) even state that this kind of software already matches approximately 80% of any service logistics company's requirements when using the standard version. Its key success factor, however, is the possibility to streamline operational processes and integrate information in order to make the best use of available resources within the company and its network (Nikolopoulos, Metaxiotis, Lekatis and Assimakopoulos, 2003). A comprehensive literature review about the development of maintenance support technology is given by Kans (2009).

The main challenges regarding technology, according to Debus (2012) are the increasing amount of data that needs to be handled intelligently as well as the increasing importance of condition monitoring in order to better predict failures and to improve preventive or even predictive maintenance. Additionally, new repair technologies are needed to be able to cost-efficiently service the customer. Hypotheses on what needs to be worked on in order to react to these technological challenges, according to Debus (2012) include end-to-end data transparency over the lifetime of all spare parts, automated identification technologies for spare parts as well as track and trace developments. Also the utilization of clouds for the data, according to the author, should be considered.

A field that is affected by these trends and that has recently gained popularity in maintenance and spare parts logistics research is the use of RFID-technology, which aims at supporting the goal to improve processes within the manufacturer's after-sales business (Ngai, Moon, Riggins and Yi, 2008). Further benefits such as increased inventory information, labor cost reductions, less stock as well as less stock-outs can potentially be generated, which again results in less costs for the OEM and thus also for the customer (Li, Godon and Visich, 2010). Additionally, the integration and relationship between partners in a supply chain may be strengthened through the use of RFID (Whitaker, Mithas and Krishnan, 2007). According to Ngai et al (2008) as well as Wang, Li, Daneshmand, Sohraby and Jana (2011), a typical RFID system within an after-sales network consists of tags and readers as well as the soft-, middle- and hard-ware to support it. With these systems, data is saved on the tags, which are then placed on a certain product or part. These tags can automatically be read by the readers wherever and whenever needed in the process (Becker, Vilkov, Weiß and Winkelmann, 2010). Despite all the possible benefits, a lot of reluctance in practice can still be seen, according to Li et al (2010). Factors that generate this reluctance, according to the authors, amongst others include the high implementation costs, unknown returns on the initial investment, little previous practical knowledge and experiences existing in research and practice, high amounts of data handling, difficult system integration, etc. Overall, it becomes clear, according to Moorman (2007) as well as Regtmeier (2012) that RFID, even though it is improving quickly, is still under development and has not reached a level where it is accepted by the majority of OEMs as well as after-sales providers yet. However, with companies such as Wal-Mart, Federal Express, Dell, Procter and Gamble, etc. having started to use RFID-technology for their respective supply chains recently, a level with sufficient knowledge and know-how in this field is being approached where it might become attractive for other companies to also look into RFID in order to support their logistics processes (Ramanathan, Ramanathan and Ko, 2014).

Another opportunity to technologically improve the after-sales business, for example, is through Functional Analysis for Maintenance (FAM) software, as suggested by Viles, Puente, Alvarez and Alonso (2007). This software automatically helps the OEM or third-party supplier to speed up the processing of corrective maintenance actions and simultaneously gathers information about why failures occurred, etc. to continuously improve itself.

With all the benefits that can be generated through technological enablers such as supportive software and hardware, it has to be stated that they generally tend to become more complex and costly in order to match the customer and internal company requirements, thus boosting problems for organizations that cannot afford major expenditures, according to Oke, Ayomoh and Oyedokun (2007).

A second major enabler for smooth spare parts logistics management is the measurement of performance (de Souza et al, 2011). Tsang, Jardine and Kolodny (1999) even identify it as a key issue for the management to take care of in order to track the organizational behavior and to motivate the employees. Neely, Gregory and Platts (1995) as cited in Tsang et al (1999) identify three levels of performance measurement. Namely, these are the distinct performance measures, the performance measurement system (PMS) and the connection between a PMS and the environment. First of all, according to the authors, any measure to be taken needs to be classified with respect to their perspectives, such as financial or non-financial, internal or external, process or equipment, etc. Then, secondly, these measures need to be put into a strategic framework and in a third step they need to be integrated into the organization and its network structure.

In this field, a large variety of research already exists as well. Approaches range from purely value-based performance measures to the Balanced Scorecard (BSC) that additionally looks at the customer, internal processes as well as the factor learning and growth (Tsang et al, 1999). Gaiardelli, Saccani and Songini (2007) add to those concepts the ideas of performance measurement matrices, performance pyramids and performance prisms as well as the results and determinants method. KPIs, their definitions, their value for the process, their analyses and their measures, which are to be taken out of the monitored results, are also a very important field in performance measurement in maintenance (Muchiri et al, 2010). Gopal and Thakkar (2012) give a comprehensive overview on performance measures in their literature review. Regardless of which approach is followed in performance measurement, however, it is important that it is done, that it is done correctly and that it is done continuously in order to derive the right next steps and measures for the after-sales service improvement of the respective company (Milliken, 2001).

Another stream of performance measurement related to service specifically includes literature on service quality measurement. One of the major frameworks in this context is SERVQUAL, which is a structured 22-step approach to measure the abstract service quality. It was introduced by Parasuraman, Zeithaml and Berry (1988). Developments to this framework, such as SERVPERF (Cronin and Taylor, 1992), which focusses on perceptions that are needed in industries such as retailing as well as performance as the only measurement for quality, were additionally introduced. A comprehensive and recent review of service quality measurement frameworks is given by Ghotbabadi, Feiz and Baharun (2015).

It can be seen that a lot of research has been done in the area of enablers as well, but potential for further research exists. New developments and research in technology, however, usually (partly) require expert knowledge from information technologists when dealing with ERP- and IT-solutions or engineers and/or chemists, physicians, architects, etc. when dealing with the design of new materials and machines. Especially RFID is a technology that still has a lot of potential to be further developed. From a logistics or business administration view point, which is represented in this thesis, however, the underlying processes to improve technology are of interest, not the design of technological advancement itself. Here, the right measurement of the performance is of key importance in order to monitor the after-sales service process in a way that improvement opportunities can be made visible, underlined by data and the right conclusions for next steps to improve the processes can be taken. As presented, a wide range of approaches exists in research that helps to make holistic performance measurements for after-sales service providers possible.

2.3.3.6 Processes

Despite the large variety of definitions for processes (Factor 4), they all similarly come to the same conclusions (Tinnilä, 1995; Psomas, Fotopoulos and Kafetzopoulos, 2011). Overall any business processes “consists of a set of linked activities or elements designed and performed by internal and external suppliers to create valued goods, services, and decisions for internal and external customers. Collectively, these processes ARE the business and need to be managed" (Wisner and Stanley, 2008, p. 5). In order to efficiently and effectively do so, Best and Weth (2010) created a model of factors influencing each process that need to be considered when looking at process excellence (see **Figure 21**).

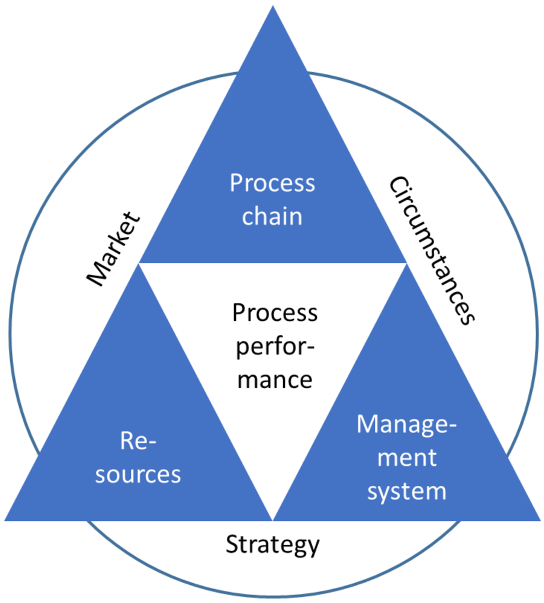


Figure 21: Framework for process excellence (Own figure based on Best et al, 2010)

In their model, Best et al (2010) describe that the core of the framework and the reason for the existence of any process is the process performance as it is the output (service or product or combination of services and products) that is used as the input of another process (internal or external). The process chain illustrates the process flow of activities to achieve the desired output and the resources describe the needed inputs for the process. Resources in this case for example are employees, machines, IT and technology, tools and equipment, raw materials, components and products, know-how and competences, etc. The management system, another factor influencing the process performance, describes the organizational structure as well as the measurements required to achieve process excellence.

The amount of literature on business process management and its optimization has been widely covered in (management) research and includes topics such as process innovation and improvement (e.g. Davenport, 1993) as well as business process redesign and business reengineering (e.g. Hammer and Champy, 2006; Limam Mansar and Reijers, 2007), etc. Within all of these approaches, a vast amount of tools ranging from TQM to Six Sigma, lean management, just-in-time, Kaizen, Poka-Yoke as well as operational and process excellence, etc. exists (Gershon, 2010). According to Davenport (1993) the goal of all of these approaches is to reduce process time, linking it to efficiency improvements and cost reductions for the process owner and value creation for the customer.

Davenport (1993) further states that it is especially important to focus on key processes within an organization that are inclusive and broad when looking at improvements as not every small process in itself has enough importance for acknowledgeable value creation. The larger the process is, however, the larger is also the potential impact through optimization. When done properly, achievements in this field can generate up to 80% savings on time and costs, according to Tinnilä (1995).

Improving service processes such as repair processes, according to Martin (2016) is very important especially to manufacturers who desire to generate competitive advantages and satisfy their customers. Furthermore, as stated by Mellat-Parast, Golmohammadi, McFadden and Miller (2015), when customer expectations are not met, financial performance of the manufacturer and/or service provider is generally affected negatively.

Processes in corrective maintenance that affect the service response time and should thus be focused on as suggested by de Souza et al (2011) include transportation, distribution, ordering, warehousing and reverse logistics. A lot of research also already exists for these processes.

Ordering of spare parts, for instance, is critical to the success of an after-sales service company (Godoy, Pascual and Knights, 2013). According to the authors, the inventory held by a company is defined by the demand generated in their service portfolio. Information about systems and end-items, lifecycle times of parts and components, etc. that can be generated through analyses, sensors, etc. can help to improve order cycles and quantities. Furthermore, Godoy et al (2013) state that another important part to consider in spare parts order management is the lead time, especially when spare parts are critical and needed immediately. If then, a servitized OEM or third-party service supplier has spare parts in their portfolio, where lead teams are long, this may cause long response times and thus dramatic consequences for the customer and needs to be avoided through optimized ordering rules and methods.

According to those factors, Giri, Dohi and Kaio (2006), for instance, suggest a model that differentiates between regular and emergency demands. Dohi, Kaio and Osaki (1996) look at a model to optimize ordering by including time-dependent delay structures, Syntetos, Keyes and Babai (2009) as well as Syntetos, Babai and Altay (2012) suggest approaches for optimized ordering through demand analysis and Godoy et al (2013) suggest the use of a mathematical ordering decision method based on the performance of the individual spare parts. According to de Souza et al (2011), just like for inventory management, for purchasing and ordering as well as sourcing, complex mathematical modelling is possible, however, the definition and control of parameters as well as the incorporation of unexpected events needs to be done manually. In this case, the differentiation and classification of items again is an important topic that needs to be considered (Syntetos, et al, 2009; de Souza et al, 2011).

Further research on ordering can also be seen in the areas of supply chain management (e.g. Bickel, 2003), where one focus area lies on managing the network of suppliers as well as research on final orders (e.g. van Kooten et al, 2009), where the problem of discontinued production of parts for an end-item is dealt with.

Also in his thesis, Bickel (2003) deals with the topic of distribution and transport. He suggests that as soon as a company offers a good or a service, it automatically requires a distribution network. This can either be organized through wholesalers, retail outlets as well as direct distribution to the end customer or a combination of methods.

According to Davies (1995) as well as Shanahan (2002), the transportation and distribution has evolved dramatically in the past years. Whereas in the 1980's a three-day delivery was normal, nowadays overnight delivery is required as a standard. Newman (2005) in his article suggests twelve focus points, e.g. smart packaging, etc. for OEM's or third-party service providers using overnight providers in order to make the most out of their services and Stapf (2013) outlines the advantage of direct delivery and pick-up of items to and from a service technicians' car or pick-point resulting in response time reduction.

When looking at warehousing processes, Baumann, Baumgart, Geltinger, Kähler, Lewerenz and Schliebner (2010) in their book give a detailed overview of the involved activities such as warehouse planning, efficient stocking, safety and cleanliness, packaging, commissioning, pricing, data management, transport, loading, etc. Furthermore, the authors also state optimization potential through tools and methods such as the previously mentioned lean management technique, Kaizen, TQM, etc. Extensive further research exists regarding optimized warehouse processes. This includes Lenius (1998) and Zeng, Mahan and Fluet (2002), who suggest improving the warehouse through a redesigned and efficient layout. Lenius (1998) adds to that the importance of state-of-the-art equipment and tools. Petersen (1999) researched the impact of routing and storage policies in a warehouse and Napolitano (2003) looks at improving warehouse worker efficiency. Another contribution to research in this area comes from Karagiannaki, Papakiriakopoulos and Bardaki (2011), who incorporate the trend towards the use of RFID-technology and the prerequisites in warehousing in their research.

Reverse logistics deals with the recovery of broken parts and/or components as well as with scrapping and reselling them and it includes the part collection, its inspection, its repair or the decision to scrap as well as the return of the part or component into the lifecycle (Choy, Chow, Lee and Chan, 2007). A comprehensive introduction and review to the topic is given by Genchev (2007) in his dissertation. Whereas, according to Mollenkopf and Closs (2005), in the past, reverse logistics was seen as a necessary cost, a compliance issue or an initiative to mirror the trends towards sustainability, nowadays more and more companies see the potential in this strategic maintenance approach.

As reverse logistics mainly have a financial impact for the company, e.g. through secondary sales and the reduction of obsolete stock, etc. as well as an effect on the overall sustainability of the company (Blumberg, 1999; Mollenkopf et al, 2005), however, not necessarily directly on process time reduction, this concept does not have a major influence on the research topic of this thesis.

Barkawi & Partner GmbH & Co. KG (2006) in an overview give more detail to the core processes of after-sales services and showed the necessary steps to be considered in (corrective) maintenance (see **Figure 22**).

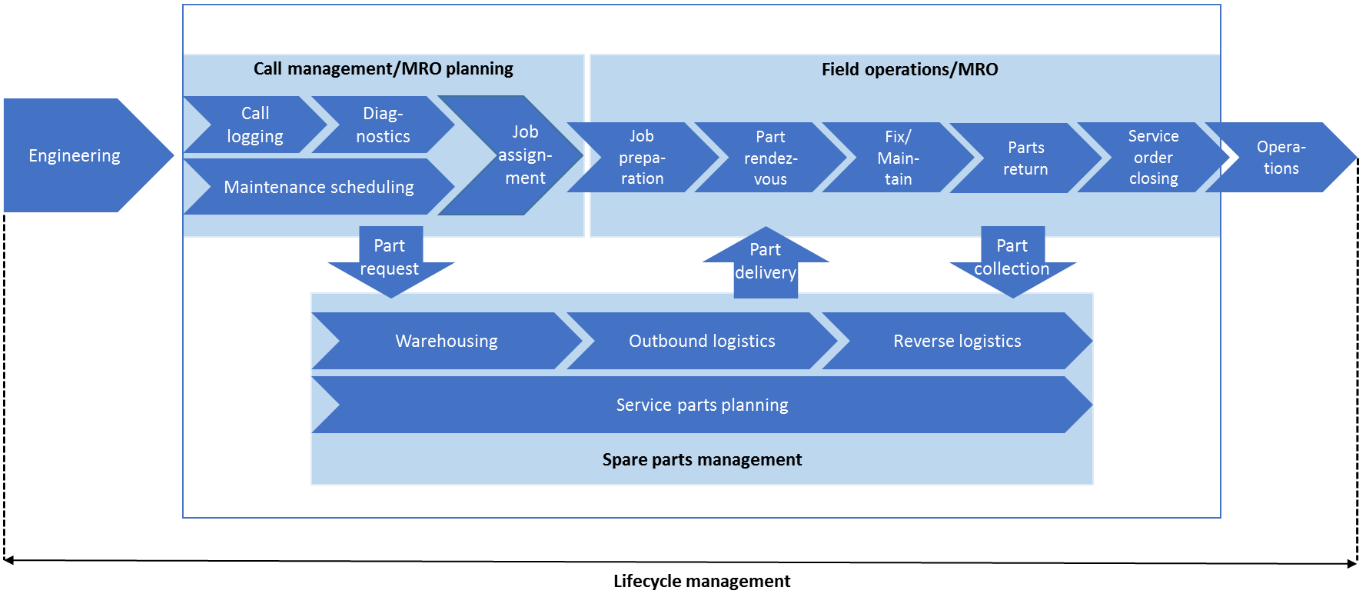


Figure 22: The extended scope of after-sales services (Own figure based on Barkawi & Partner GmbH & Co. KG, 2006)

They separate their model into three main areas dealing with after-sales services. The first one being the call management and MRO planning, which deals with the incoming call from the customer, the diagnosis of the problem and the appropriate assigning of a service technician to fix the problem. Spare parts management is the second major area. Here, warehousing, outbound and reverse logistics as well as the spare parts planning is handled. The third area is the field operation, where, as soon as the needed part(s) have arrived, the service technician starts to maintain or repair the end-item or system and finishes the job (Barkawi & Partner GmbH & Co. KG, 2006). In their diagram, it becomes clear that the (corrective) maintenance process is very complex and deals with a large number of sub processes that can be influenced in order to optimize the response time.

Even though the field of spare parts process optimization has a large amount of research that looks at a lot of different factors, what seems to be missing in this field of research, are a couple of things. First and foremost, the role of the service technician seems to be neglected in this process, thus showing a gap in literature. Ngai, Cheung, Lam and Ng (2014) in their study point out that in aircraft maintenance, for instance, the most urgent need is to quickly identify which part needs to be exchanged. In their paper they point out the high value that RFID plays in this field. What happens, however, if a company does not have this technology for reasons such as costs, a portfolio of parts that largely consists of items that are too small to be tagged with an RFID-chip or a portfolio of end-items and systems that largely consists of third-party fabricates, which does not have RFID-chips on their key components, etc. is not considered. In these cases the role of the service technician seems critical. Furthermore, Stapf (2013) suggests that the typical pattern of a service technician after identification includes ordering the part and usually picking the part up in whichever stock location it is available. Also, according to Stapf (2013) it is common for service technicians to exchange parts among each other in urgent cases. If those movements are not registered in the supporting ERP-system, wrong stock keeping analysis, wrong ordering suggestions and wrong invoicing to the customer may be the consequences. Ordering, parts receiving and communication play a vital role and the service technician seem to have a high impact on it. This, however, has not yet fully been considered in research, to the best knowledge of the author.

2.3.3.7 People

Just like for the other factors mentioned by de Souza et al (2011), there is a wide array of literature available for Factor 5 of de Souza et al's (2011) framework, i.e. people, as well.

Peter Drucker (as cited in Dobmeier, 2016) states that the greatest challenge for managers and businesses in developed countries today is to raise the productivity of knowledge and service workers. Especially spare parts logistics and its management, according to de Souza et al (2011), thereby largely depend on the people executing it. Technology and high standard-equipment can generate an environment for efficient processes and high service levels, yet if well-trained people are not involved, the outcome will very likely still be unsatisfactory for both the service provider as well as the customer. This is supported by Slack et al (2014), who state that operations of companies are usually presented to focus on processes, technologies, facilities, systems, etc. Oftentimes, the human component is not mentioned within this context. This, according to them, should be the case, however, as the management of human resources has a major influence on the effectiveness and efficiency of the organizational operations.

Slack et al (2014) therefore dedicate an entire chapter in their book to the human factor in organizations and operations. In this chapter, they cover topics such as the human resources strategy for an operation, organizational structures, job design and task allocation as well as the interdependencies between those points.

A large amount of literature also focusses on human resources as a source for the generation of competitive advantages as part of the resource-based view (e.g. Barney, 1991; Wright, McMahan and McWilliams, 1994; Mata, Fuerst and Barney, 1995; Barney and Wright, 1998;

Ray, Barney and Muhanna, 2004; Barney, 2012). The resource-based view thereby suggests that competitive advantages can be created through three different types of resources (Barney, 1991, Barney et al, 1998). Namely, according to the authors, these besides the physical capital, e.g. plants, buildings, equipment, vehicles, etc., as well as organizational resources such as structures, planning abilities, coordination and systems, etc. are human resources. Human resources include skills, intelligence as well as judgement. Competitive advantages in these three categories can be generated, according to Barney (1991), when they create additional value, when they are rare, when they are imperfectly imitable and when they are sustainable, thus showing the importance of human resources in operations.

In line with the resource-based view, further literature, e.g. Ployhart, van Iddekinge and Mackenzie Jr. (2011), elaborate the potential of front-line human resources, i.e. service employees, as sources for sustained competitive advantages, Chae, Olson and Sheu (2014) look at the impact of supply chain analytics on organizational performance, and Moser, Kuklinski and Weidmann (2014) analyze the outside impacts, e.g. institutions, on human resources.

General trends, such as the effects of servitization on human resources (Gebauer, 2007; Raja, Green and Leiringer, 2010), the effects of skilled human resources in logistics and supply chains in China (Kam, 2010; Ding, Kam, Zhang and Jie, 2015), the importance of human resources in mainly service-oriented organizations (Kaiser, Kozica, Swart and Werr, 2015), capturing value created by human resources (Molloy and Barney, 2015) as well as understanding and managing service productivity (Dobmeier, 2016), etc. receive increasing attention in literature and research lately as well.

With specific focus on after-sales services and spare parts logistics, especially scheduling of service technicians seems to find a lot of attention in research (Quintana et al, 2002). Beliën, Demeulemeester, de Bruecker, van den Bergh and Cardoen (2013) for instance in a recent article look at a mathematical model to integrate staffing and scheduling, and Goel and Meisel (2013) work on scheduling and routing in their paper. Haugen et al (1999) look at travel time reduction through scheduling, Quintana et al (2012) suggest using relay-type assignments for technicians and Sun, Chiu, Gong, Meng and Zhang (2012) look at optimized assignments of maintenance workforce with regards to qualification and location. A more detailed literature review on scheduling is given by Alvarez (2013).

Further research, amongst others, for example deals with the incorporation of employee mistakes in maintenance (Carr and Christer, 2003; Shanmugam and Paul Robert, 2015), integration of differences between workers' skills, know-how, personalities, etc. (Othman, Bhuiyan and Gouw, 2012), differences in productivity (e.g. Thompson and Goodale, 2006) as well as motivation (Hays and Hill, 2001; Mak and Sockel, 2001; Othman et al, 2012) within a workforce. A combination of motivation of workforce as well as learning from failures and its effects on service for the customer is given by Hays and Hill (2006). Overall, according to de Souza et al (2011), it is essential to put the right people with high skills, experience and motivation, vision and attitude in the key positions in order to successfully generate low response times in after-sales services, i.e. spare parts logistics.

Even though a large body of literature exists with regards to human resources, besides what could be seen in **Chapter 2.3.3.6** on processes, this chapter again emphasizes the role and importance of service technicians in operations management, servitization, the generation of competitive advantages, and specifically also creating efficient and effective spare parts logistics and corrective maintenance processes. Once again, the value service employees can create in this context through efficient and quick process delivery with a high customer orientation and service level, can be of major importance for servitized/servitizing companies. As pointed out before, the specific role of service technicians in the corrective maintenance process therefore needs to be looked at in further detail as well as the factors affecting them in this process, providing a gap in literature for research.

2.3.3.8 Others

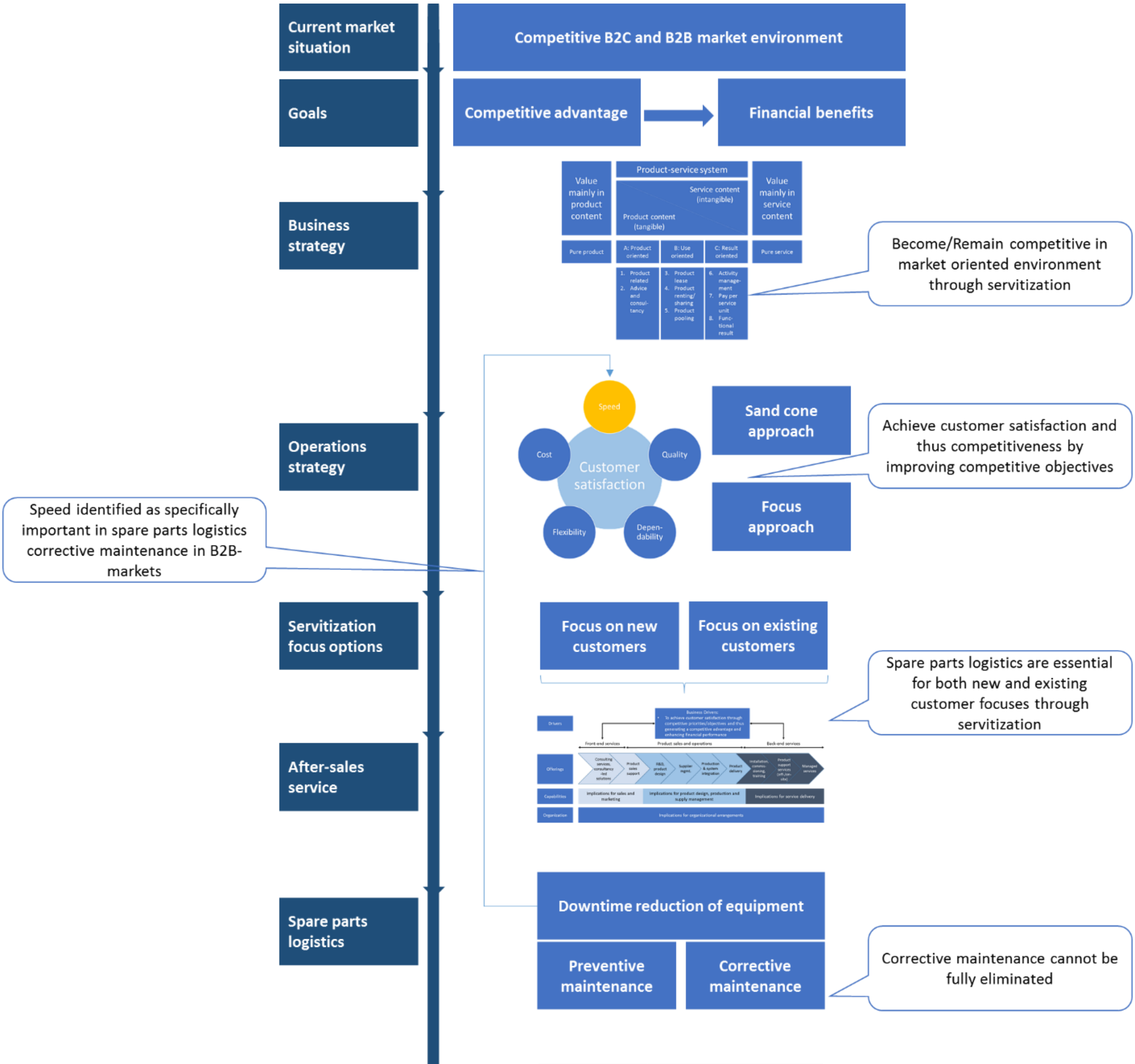
Factor 6 in de Souza et al's (2011) framework consists of external influences on the response time such as customs, government regulations and laws as well as the infrastructure, etc. Even though these factors need to be considered and the processes need to strictly comply to the different settings in different regions in order to be efficient and quick (de Souza et al, 2011), these factors as already and previously mentioned by Pfohl (2004) cannot be easily influenced and usually simply need to be accepted as given circumstances.

For the purpose of this literature review, this factor will not be further considered in more detail.

2.4 Intermediate conclusion and identification of research gap

To conclude, the literature review conducted clearly shows need for further research in the after-sales service field of spare parts logistics optimization.

While an extensive amount of research already exists in this area, further research needs could be identified through the approach chosen to drill down the topic. This drilldown is displayed in **Figure 23**.



Influence factors	Examples
1) Customer service objectives and goals	• Efficiency improvement • Customer satisfaction • Response time reduction
2) Supply chain network	• Network configuration
3) Enablers	• Technology • Measurements • Air and sea connectivity
4) Processes	• Transportation • Warehousing • Reverse logistics • Order processing • Distribution
5) People	• Skill sets • Knowledge • Training
6) Others	• Infrastructure • Government regulations • Incentives

Figure 23: Reconstruction of identification of research gap

The literature review showed that companies in B2B and B2C markets today operate in an increasingly competitive market and customer oriented environment. In order to stick out of the mass of similar offerings, it is essential for those companies to generate competitive advantages that let them create financial returns and thus operate a profitable business.

A competitive advantage is created when the customer is more satisfied with a company's offering over another competitor offering. This can be created either through financial incentives or through added value differentiation, which again can be high quality, dependability, speed/timeliness and responsiveness, as well as flexibility. By working on these competitive objectives, a company improves its operations in such a way that the customer can be satisfied and a competitive advantage may be created or strengthened.

Furthermore, in this literature review the importance of linking the operations management as well as operations strategy to a company's business strategy was identified. The business strategy, i.e. servitization in this case, defines in detail, how competitiveness can be achieved in the market and customer oriented environment that companies operate in today. By adding services to products in various forms and degrees, i.e. PSS, higher value and solutions are generated that benefit the customer and create satisfaction. Those services thereby are closely linked to the previously explained competitive priorities defined through the operations strategy. Operations strategy can be seen as a sub-section of the total business strategy and is necessary for the company to ensure operations make the required contributions to the business' strategy.

It could also be seen that servitization may have two different underlying strategic intentions. On the one hand, servitization can be used to approach new customers. On the other hand, it can also be used to strengthen existing relationships. Given the various services that can be added to a product prior to production, e.g. consulting, sales support, etc. as well as in the after-sales market, e.g. installation and commissioning, spare parts logistics, maintenance and repairs, etc., the literature review identified spare parts logistics and management to be of especially high importance. While they are required for both preventive as well as corrective maintenance services and thus form part of both new customer as well as existing customer focus servitization strategies, they also form the backbone for all types of PSS.

Having identified the importance of spare parts logistics, the literature review showed the specific need for downtime reduction of customer equipment. While all other competitive objectives identified previously are important in spare parts logistics as well, specifically the competitive priority of timeliness/speed plays a crucial role in spare parts logistics. This is the case because companies, especially in high-value stationary B2B equipment markets, cannot afford for those machines not to operate as it generally means high production and margin losses. While concepts such as preventive maintenance boost opportunities to eliminate downtimes, corrective maintenance needs due to sudden, unpredicted break-downs cannot be eliminated completely and therefore will consistently be of high importance for further research. This field was therefore chosen to be looked at in this thesis.

Moreover, the literature review also revealed that whilst speed/timeliness is seen as the key objective in this concept of reducing response time and thus unit downtime, the other competitive objectives identified in the literature review need to be addressed as well. In case of utilizing the sand cone model, improvements in speed are recommended only to be looked at when quality and dependability have been improved, for instance. By utilizing a focus approach on speed/timeliness, the other objectives have to be addressed in a balanced way in order to minimize trade-offs on them.

Within this research, it is therefore the goal to add clarification and knowledge around the competitive objectives in stationary equipment corrective maintenance, to address in more detail the competitive objectives besides timeliness/speed and their effect on it, to identify similarities and differences across different business areas and to identify, if additional competitive objectives may be applicable in this context and thus need to be added to the frameworks available in literature. Hence, the first research question for this thesis is:

1. What are the competitive objectives for stationary equipment corrective maintenance processes within the different business areas, i.e. elevator, mining equipment and IT hardware, they serve and how do they impact service response time?

Besides a focus on the overall competitive objectives in corrective maintenance processes for stationary equipment, and given the identified importance of speed/timeliness in the literature review, six factor groups that may have an effect on response time in corrective maintenance and thus downtime reduction were identified. These six factor groups, i.e. customer service objectives and goals, supply chain network, enablers, processes, people, and others were looked at in detail in this literature review to identify potentials for research to optimize spare parts logistics corrective maintenance response time reduction.

While numerous gaps with respect to these factors could be identified in literature and thus research needs could described, e.g. the need to enhance mathematical models in supply chain network optimization to overcome their limitations, as well as the need to further research hard- and software potentials as enablers for smooth maintenance processes especially with the rising costs and complexity of such systems, most relevance for further research was identified to be present in the role of service technicians in this concept. Not only was this need clearly identified in two factor categories, i.e. processes and people, but service technicians and personnel may also play an important role for the other factors looked at, as they are the ones that need to live the strategic implications and need to handle and operate enablers such as technology and performance measurement systems correctly and effectively, etc. in order to utilize the full competitive potential of these factors.

Even though the literature review also identified a large amount of research within human resources in after-sales services, logistics and spare parts management, it was clearly identified that, despite their important part in this concept, research regarding the role of service technicians in corrective maintenance response time for stationary equipment and factors affecting them in this process has not been explored in much detail so far and is therefore needed. This will therefore add to the focus of this thesis. Three additional research questions and objectives have been identified to address this need in more detail and add onto the general competitive objectives addressed in the first research question. The respective questions and their objectives are therefore displayed below. The second research question is:

2. In the corrective maintenance processes in the three business areas described, what factors are perceived as affecting the service technicians' response time performance?

Given the identified importance to constantly optimize response times and speed in corrective maintenance to react to broken down units, with this step it is the aim to specifically identify factors that are perceived to have an impact on the service technicians' service response time in the different business areas and thus influence the objective of timeliness/speed negatively.

Building on this question, the third research question is:

3. What is the perception towards how the process can be altered to better serve the service technicians' needs, i.e. to minimize response times in corrective maintenance?

With the perceived factors influencing the service response time in stationary equipment corrective maintenance in the different business areas identified in the previous question, this question aims at identifying potential process alteration opportunities that are perceived to improve the service technicians' needs, i.e. to minimize response times in corrective maintenance and thus improve the objective of timeliness/speed and thus satisfy the customer.

Finally, the last research question to be addressed in this research is:

4. How can a consensus construction be developed in order to identify what needs to be taken into account to introduce these alterations in business practice?

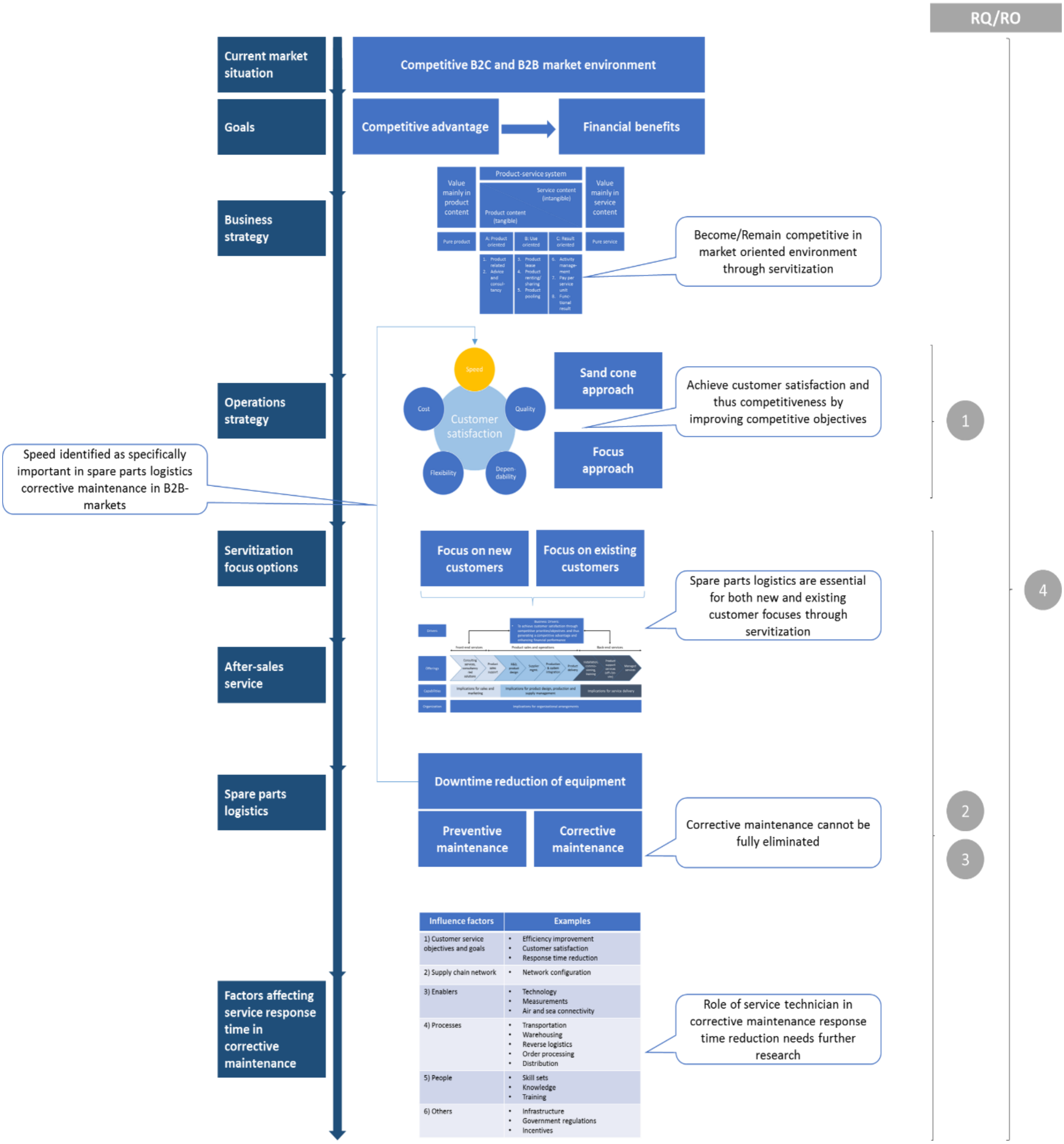
With the generated input in terms of competitive objectives, perceived influence factors on service technicians in stationary equipment corrective maintenance response time processes as well as perceived improvement opportunities, it is the aim to provide a consensus construction that demonstrates what needs to be taken into account to introduce these findings in business practice in the community studied. Furthermore, it is the intention with this construct to build a baseline for further research.

An overview of the four research questions and their adjacent research objectives is displayed in **Table 2**.

#	Research question	Research objective
1	What are the competitive objectives for stationary equipment corrective maintenance processes within the different business areas, i.e. elevator, mining equipment and IT hardware, they serve and how do they impact service response time?	To identify the competitive objectives and their impact on response time in stationary equipment corrective maintenance processes.
2	In the corrective maintenance processes in the three business areas described, what factors are perceived as affecting the service technicians' response time performance?	To identify factors that are perceived to have an impact on the service technicians' service response time.
3	What is the perception towards how the process can be altered to better serve the service technicians' needs, i.e. to minimize response times in corrective maintenance?	To identify potential process alteration opportunities that are perceived to improve the service technicians' needs, i.e. to minimize response times in corrective maintenance.
4	How can a consensus construction be developed in order to identify what needs to be taken into account to introduce these alterations in business practice?	To provide a consensus construction that demonstrates what needs to be taken into account to introduce the findings around competitive objectives, perceived influence factors and perceived improvement opportunities in stationary equipment corrective maintenance processes in the community studied.

Table 2: Research questions and research objectives

In the context of the framework developed from the results of the literature review (**Figure 23**), the research questions and objectives can also be shown with regards to what they address specifically. While the first research question and research objective aim at clarifications and added knowledge on the general competitive objectives with regards to corrective maintenance, the second and the third research questions and objectives then specifically address points and knowledge creation on the main competitive objective in corrective maintenance, i.e. speed/timeliness through the optimization of response times. The final research question and research objective utilize the findings in order to create a baseline to improve competitiveness of the participants of the study and therefore add to the overall concept. This is displayed in **Figure 24**.



Influence factors	Examples
1) Customer service objectives and goals	• Efficiency improvement • Customer satisfaction • Response time reduction
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4) Processes	• Transportation • Warehousing • Reverse logistics • Order processing • Distribution
5) People	• Skill sets • Knowledge • Training
6) Others	• Infrastructure • Government regulations • Incentives

Figure 24: Context of the research questions and objectives in the framework developed based on the literature review

This structured literature review on this given topic, the specific need for research in this area identified, the other identified gaps in research as well as the displayed connections between topics as displayed in **Figure 23** and **Figure 24** thereby already demonstrate first contributions of this thesis to research and knowledge.

3 Research approach

3.1 Aim and approach

Research in social sciences, which includes business management research, usually aims to solve a real-world organizational problem (Bryman and Bell, 2011). Oftentimes, the personal experiences and interests of the researcher are a starting point for research in this area (Bryman et al, 2011). In order to create results in one's research, according to Yin (2014), different options are available for the academic investigators. Obviously, all of these options have certain advantages and disadvantages. The type of research chosen largely depends on the research philosophy as well as the research methodology, which questions are asked, how much control over the researched incident the scientist has and whether the researcher is focussed more on recent or historical events and data.

In this research, the goal of the author is to create a consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance.

In the next chapters therefore, an overview of different research philosophies is given and the choice for this thesis is outlined, the adjacent options with regards to the research methodology are displayed and a justification for the chosen approach is given. This approach will then finally be transferred and explained in the context of this thesis. Furthermore, the importance of bias minimization as well as ethical considerations is displayed in this chapter.

3.2 Research philosophy

According to Saunders, Lewis and Thornhill (2009), the researchers' own values (may) have an influence on the way their research is conducted. The authors further state and are supported by Guba and Lincoln (1994), that to define one's own research philosophy therefore is a very important part of the research process and needs to be conducted before methodologies and methods can be chosen, as these largely depend on the standpoint respectively the research philosophy of the researcher.

The research philosophy, according to Kilduff, Mehra and Dunn (2011), deals with a range of different scientific approaches that come in line with different ontological and epistemological assumptions taken by the researcher. While, according to numerous authors (e.g. Guba et al, 1994; Saunders et al, 2009; Bryman et al, 2011; Kilduff et al, 2011; Easterby-Smith, Thorpe and Jackson, 2012) the ontology deals with the view of the academic on reality and/or being, the epistemology deals with the view on what creates knowledge, how this can be accessed and what the relationship between the knower and what can be known is.

A large variety of philosophical approaches with different ontologies and epistemologies exists. Saunders et al (2009) for instance name positivism, realism, interpretivism and pragmatism as major philosophies in management research. Guba et al (1994) differentiate between positivism, post positivism, critical theory and constructionism as well as cross-paradigms combining different philosophies. Easterby-Smith et al (2012) name realism, internal realism, relativism and nominalism as four major ontologies and add strong positivism, positivism, constructionism and strong constructionism as the corresponding epistemologies. Furthermore they name critical realism, critical theory, hermeneutics, pragmatism, feminism and postmodernism. Kilduff et al (2011) add structural realism, foundationalism, instrumentalism, the strong paradigm as well as critical realism to the list. A critical review on the multitude of these paradigms is given by Mkansi and Acheampong (2012).

In social sciences and particularly in organizational studies as well as management research, increasing popularity and a shift towards more (social) constructionist approaches has been recognized by numerous authors in the last decades (e.g. Cunliffe, 2008; Refai, Klapper and Thompson, 2015). Mir and Watson (2000, p. 950) specify this development by stating the fact that management research "is a public, social practice, and hence that knowledge is the product, not of isolated individuals, but of intersubjective relations between members of research communities."

The underlying ontology in this approach, according to authors such as Guba et al (1994) or Easterby-Smith et al (2012), is relativism, stating that there are many truths and that these depend on the viewpoint of the observer. Guba et al (1994) as well as Lincoln, Lynham and Guba (2011) add that this ontology evolves around experientially based realities, which are socially constructed and are usually locally specific. However, the authors add, that elements can be and/or are shared among cultures or larger groups or individuals oftentimes.

Furthermore, Andrews (2012) as well as Ariño, LeBaron and Milliken (2016) through their papers describe this paradigm as accepting that there is both an objective and a subjective reality, which is taken as given. Additionally, as stated by Andrews (2012), the focus of this paradigm lies in the nature of knowledge as well as its creation through interactions of people in society. The difference of social constructionism to constructionism thereby is that a social rather than an individual focus is used (Young and Colin, 2004 as cited in Andrews, 2012; Easterby-Smith et al, 2012).

Social constructionism, according to numerous authors (e.g. Mir et al, 2000; Järvensivu and Törnroos, 2010; Elder-Vass, 2012a; Elder-Vass, 2012b) is oftentimes also seen as opposing or contradictory to realism, which states that there is only one truth and it is possible to know exactly what it is. However, as pointed out by Järvensivu et al (2010) and Elder-Vass (2012a), there are forms both of realism as well as relativism, that are more moderate and accept the existence and even share some elements of the other extreme.

Two examples are critical realism as well as moderate (social) constructionism. Critical realism, on the one hand for instance, according to Järvensivu et al (2010), while stating that only one true reality exists, shares the belief with relativism that there are limits to how precisely the truth can be known. The endeavour of this ontology is to move in the direction of understanding reality, while strong realism aims at fully modelling reality. Moderate constructionism on the other hand, while stating that multiple viewpoints to knowledge exist, contrary to strong relativism does not necessarily and primarily aim at studying knowledge and the adjacent creation process, but much rather aims at creating new knowledge and truth based on multiple different viewpoints, dialogs and discussions as well as consensuses in different communities, between different parties and people as well as between researchers and participants.

Moderate social constructionists, according to Järvensivu et al (2010), therefore generally aim at community-based knowledge creation through empirical observations as their methodology of research. The goals thereby, similarly to interpretevists, for moderate social constructionists lie in “understanding the world of lived experience from the perspective of those who live in it” (Andrews, 2012, p. 40).

Additionally, Andrews (2012) states that social constructionists thereby rely on the plausibility of their research results, i.e. a high acceptance through high validity in their argumentation and reasoning rather than stating that the outcomes are final and definite. Their target, according to the author, is to generate debates and thereby creating change and an improved knowledge base on a given subject. This is supported by Guba et al (1994), who state that constructivists through hermeneutical and dialectical approaches aim at redefining individual knowledge bases and viewpoints through interaction and communication between parties. The overall target thereby, according to the authors (Guba et al, 1994, p. 111), is “to distil a consensus construction that is more informed and sophisticated than any of the predecessor constructions.”

The author shares the standpoint of moderate social constructionism. Applying it to this research means to find a way to create a shared understanding and knowledge base of the context as well as the problems in order to achieve solutions in the most beneficial way for the community studied and not only its individuals. It is the aim to create a more informed and structured baseline on the given topic. This will be done through incorporating different viewpoints, expert knowledge, etc. and a research design carefully chosen to match the paradigm/philosophy. It is thereby the intention to answer the research questions and fulfil the research objectives. The claim for consensus in this approach in essence is thus contextually bound to those who the research considers and limits the generalization of the results to the parties involved in this research.

In order to generate community-based local knowledge and a consensus construction through empirical observations, the previously mentioned research methodology has to be specified in more detail.

3.3 Research methodology

3.3.1 Justification for an abductive research approach

First of all, a decision has to be made with respect to the relationship between theory and research. According to Bryman et al (2011), deduction is the most common view on relationships between theory and research. By using a deductive approach, on the one hand, as stated by the authors, the researcher starts off with what is already known and creates hypotheses to be tested, according to the underlying theories. After that, data collection will be conducted before findings in the generated data will be analyzed. These findings then either confirm or reject the hypotheses, resulting in a possible revision of the theories.

Induction, as suggested by Bryman et al (2011), on the other hand, changes this approach around. Findings generated through research in this case are generalized to create a theory. The different approaches are displayed in **Figure 25**. Overall, however, both deduction as well as induction include a bit of the other approach in themselves (Bryman et al, 2011).

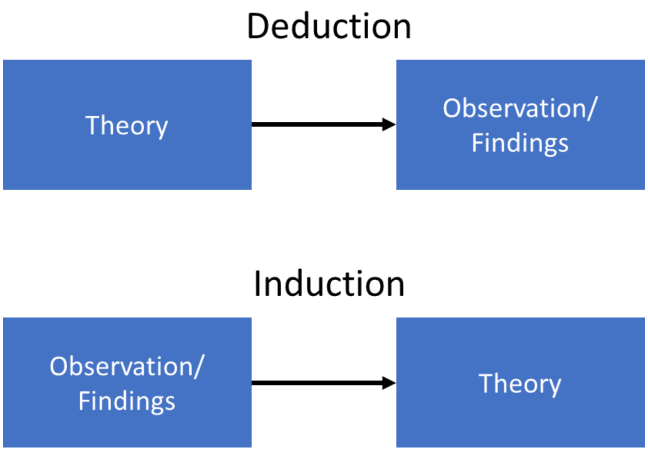


Figure 25: Deduction versus induction (Own figure based on Bryman et al, 2011)

According to Järvensivu et al (2010), deduction is usually used in strong realism, while strong relativists generally tend to use induction. In moderate social constructionism, however, the authors argue that abduction, which can be categorized as in between deduction and induction, is the most suitable approach.

While, according to Woo, O'Boyle and Spector (2017), deduction means to generate a logical conclusion based on true premises, and induction means to take the given results and generalize beyond them, abduction is about explaining and generating theories with regards to the reasoning of particular occurrences. According to Järvensivu et al (2010, p. 102), “unlike induction, abduction accepts existing theory, which might improve the theoretical strength of case analysis. Abduction also allows for a less theory-driven research process than deduction, thereby enabling data-driven theory generation.” Järvensivu et al (2010) adds that the abductive approach thereby generally includes parts of induction as well as deduction during the research process. As stated by numerous authors, e.g. Järvensivu et al (2010), Mingers (2012), Rennemo and Åsvoll (2014), Folger and Stein (2017) and Woo et al (2017), C.S. Peirce is recognized to have introduced this concept to research.

In the author’s research, which follows a moderate social constructionist approach, therefore an abductive approach is chosen to contribute to closing the identified research gap by answering the research questions and fulfilling the research objectives. The conducted literature review has created a theoretical baseline and understanding of the topic, which led to the formulation of research questions. The empirical results of this research will be used to generate explanations and reasoning to community-based local knowledge and improve the knowledge base on the given subject by creating a consensus construction.

3.3.2 Justification for a qualitative research approach

Second of all, a decision has to be made with respect to the data that is aimed to be retrieved through the research.

Traditionally, especially medical scientists, among others, have focussed their research on quantitative approaches (Petticrew, 2001; Tranfield et al, 2003). The quantitative approach, according to Bryman et al (2011, p. 26) is

> a research strategy that emphasizes quantification in the collection and analysis of data and that:
>
> - entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories;
> - has incorporated the practices and norms of the natural scientific model and of positivism in particular; and
> - embodies a view of social reality as an external, objective reality.

In recent years, however, as Petticrew (2001) states, the misconception about mainly quantitative studies being valuable sources for research has been updated. The trend and interest, especially in social sciences and applied fields, for instance psychology, organizational studies, business management, education, etc., has shifted towards the utilization of qualitative approaches more and more, according to authors such as Miles, Huberman and Saldaña

(2014) as well as Flick (2009), etc. Flick (2009, p.12.) states that this is mainly a result of postmodernists arguing that "the era of big narratives and theories is over. Locally, temporally, and situationally limited narratives are now required." Furthermore, Flick (2009) states that the limitations of quantitative research, especially with regards to their rare utilization in everyday life and practice, have developed the need for more qualitative research. Tranfield et al (2003) support this by arguing that due to the heterogeneity of studies, especially in the field of management research, it is usually simply impossible to answer research questions by looking at a number of studies concerned with the same problem and evaluating and synthesizing the results with one of the quantitative approaches.

Much rather, in social sciences and therefore also in management research (Tranfield et al, 2003; Flick, 2009; Miles et al, 2014), and especially when observing processes (Denzin and Lincoln, 2005 as cited in Jahns, Darkow and da Mota Pedrosa, 2007), the majority of findings nowadays come through synthesizing qualitative data. The qualitative approach, according to Bryman et al (2011, p. 27) is

> a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data and that:
>
> - predominantly emphasizes an inductive approach to the relationship between theory and research, in which the emphasis is placed on the generation of theories;
> - has rejected the practices and norms of the natural scientific model and of positivism in particular in preference for an emphasis on the ways in which individuals interpret their social world; and
> - embodies a view of social reality as a constantly shifting emergent property of individuals' creation.

Miles et al (2014) list a number of major strengths of qualitative data. One major strength, according to the authors, is that it includes the focus on "naturally occurring, ordinary events in natural settings" (Miles et al, 2014, p. 11). This means that real life scenarios and situations are covered and explored. Furthermore, the authors state that the researcher in qualitative research is generally in very close proximity to the action and researches a very specific case or a very specific number of cases with openness to unexpected events. To be even more precise, it thereby is the goal of the researcher to identify, understand and include these unexpected events in the research rather than leaving them out in order to get a full picture of the situation, its processes and the people involved. Through the inclusion of people's real life experience, meanings with respect to organizations, processes and structures as well as perceptions and assumptions, etc. can be identified and put into context.

By applying qualitative research, Miles et al (2014) also state that complex situations have a high chance of being revealed and can then be explained to interested audiences and thus create benefits that are applicable. Furthermore, the flexibility of qualitative studies in terms of data collection, the methods to be applied to retrieve and generate data, etc. as well as the aim to study and understand processes and structures over a specific period of time helps explain situations and problems in high detail. Furthermore, Miles et al (2014) also state that qualitative studies are the best approach when new fields need exploration and discovery, when hypotheses need to be tested and also when quantitative data needs validation and confirmation, more explanation or add-on knowledge to support or dismiss arguments, etc.

Given the benefits of qualitative research, Flick (2009) point out that a large variety of approaches to qualitative research exists. These can vary from subjective starting points to studying and researching interactions or aiming at identifying and explaining structures and their meaning, according to the author.

While not neglecting the limitations to qualitative research, for example as outlined by Bryman et al (2011), who mention that quantitative researchers often state that qualitative research may sometimes be too subjective, difficult to replicate and generalize, and sometimes lacks transparency, in line with the moderate social constructionist position of the author, who aims at developing a consensus construction around understanding and enhancing knowledge on the given subject for the limited community that participated in the research, qualitative research is viewed as the most appropriate approach for the author's research and will therefore be utilized.

The advantages that qualitative research can generate for knowledge creation, according to Miles et al (2014), heavily rely on the way and the competences with which the analysis is conducted. The authors explain that the data analysis thereby consists of four components: data collection, data reduction, data display, and conclusion drawing/verification. The latter three form the actual analysis of the collected data and usually occur simultaneously and interconnected throughout the research. **Figure 26** shows the relations between these components.

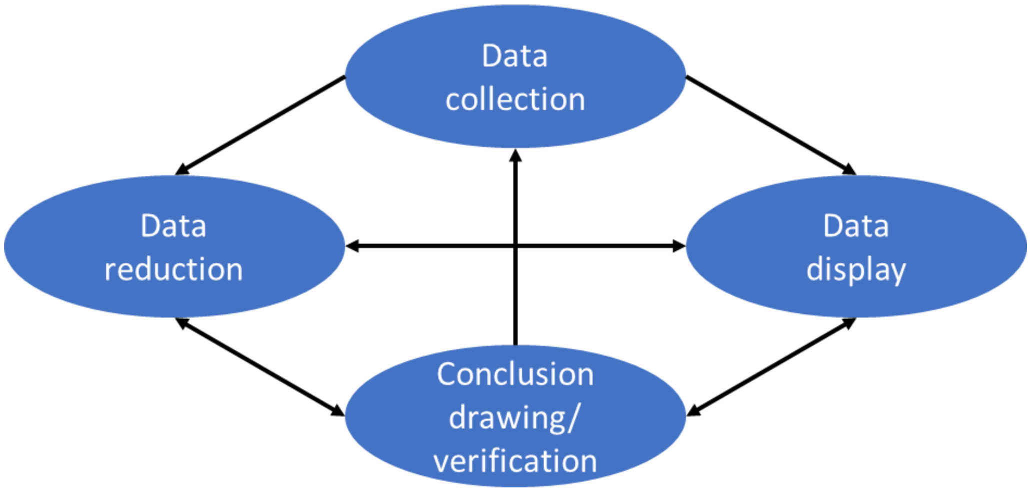


Figure 26: Components of data analysis (Own figure based on Miles et al, 2014)

According to Miles et al (2014), data reduction deals with the decisions and process steps with regards to what data actually will be included in the notes and the final report of the research. This process not only takes place throughout the research, but also beforehand, when decisions with regards to what will be analyzed, what the research questions are, how the data is collected, etc. are made. During the research, data reduction takes place through multiple forms of selection, simplification, abstraction, etc. of the data generated. This process is then repeated multiple times throughout the research and data reduction reoccurs also in different formats, e.g. summarizing data, coding and/or clustering, etc. until a final report has been extracted from the original data in the end. It can be seen as the researcher's tool to structure the outcomes of the data generated throughout the research.

With regards to data display, Miles et al (2014) state that this is the way information can be condensed to something meaningful and understandable as well as a tool to draw conclusions and actions from. The authors state that large amounts of text and information are usually hard to process for human beings and it is therefore necessary to display complex information and data in easily understandable displays. These can include graphs, matrices, tables, charts, illustrative figures, etc. They also state that displays are a major contributor to valid qualitative analysis.

Conclusion drawing and verification also occur throughout the entire data analysis process, according to Miles et al (2014). The researcher during this process will always ask himself/herself, what the data collected means, even during inductive approaches. However, until final and explicit conclusions can be made at the end of the research, the authors state that it is recommended to keep the conclusions to a minimum during the research process in order to stay open and sceptic. Verification of the conclusions is just as important as deriving them, according to Miles et al (2014). The range of verification thereby ranges from checking notes again to validate a statement all the way up to reviewing and arguing conclusions in depth with other experts or to aim at replicating results. This, in the end, provides validity of the data and the conclusions drawn.

Overall, according to Miles et al (2014), to derive with a valid qualitative data analysis is an iterative process that includes the components described and needs to be well documented.

Besides deriving valid results in qualitative research through reviews and/or the replication of results, especially in (moderate social) constructionist approaches, where there may be multiple different viewpoints and perceptions, another important factor to generate valid conclusions is to use triangulation (Easterby-Smith et al, 2012). Triangulation thereby simply means to use more than one method, data input, study group, etc. in order to generate results (e.g. Creswell, Hanson, Plano Clark and Morales, 2007; Della Porta and Keating, 2008; Flick, 2009; Bryman et al, 2011; Easterby-Smith et al, 2012; Yin, 2014) and to answer the research questions based on different perspectives (Flick, 2009). The idea behind triangulation, according to Flick (2009), is to generate knowledge that would not have been generated, if only one of the methods or data points included in the research had been utilized.

Specifically for qualitative research, Lincoln and Guba (1985) add credibility, dependability, confirmability and transferability as key criteria to keep in mind in order to generate rigorous results. Credibility thereby means to achieve confidence in the validity of the results, e.g. through triangulation as explained beforehand. Dependability focusses on the consistency of the results and can be assured through an auditing mechanism, which ensures that a complete record of the research exists and is checked during the course of the research, for instance (Bryman et al, 2011). Transferability describes the applicability of the derived data in other contexts. Here, however, according to Bryman et al (2011, p. 398), the goal unlike in quantitative research is not to generalize beyond the "contextual uniqueness and significance of the aspect of the social world being studied." Much rather, a detailed description of this community-based knowledge generation then provides interested audiences with a baseline or a "database for making judgements about the possible transferability of findings to other milieux" (Bryman et al, 2011, p. 398). Confirmability focusses on the degree of neutrality, e.g. results based on participants' answers rather than the researcher's bias.

3.3.3 Justification for a multiple case study approach

Third of all, the choice of methodology and methods to conduct the research has to be chosen for the abductive, qualitative research approach.

Here, as shown in an overview given by Merriam (2009), a vast number of authors state a large variety of different methodologies applicable in qualitative research. A general observation, as stated by Merriam (2009) thereby is that these, regardless of the quantity of different approaches identified amongst all authors, can generally be categorized in classical and familiar approaches such as ethnography and grounded theory, as well as in less common methodologies such as semiotics and/or chaos theory. Padgett (2017) in her most recent book names the six primary approaches utilized in qualitative research methodology thereby to be ethnography, grounded theory, case study analysis, narrative approaches, phenomenological analyses as well as action and community-engaged research.

When looking at abductive qualitative research as a social constructionist, Outhwaite (2007) points out that in social sciences, especially ethnographic, comparative, historical as well as case analyses are the most common methodologies. In the paradigm of constructionism, Easterby-Smith et al (2012) point out that the major methodologies for research usually are action research and cooperative inquiry, archival research, ethnography, narrative methods, the case method and grounded theory or a mix of these. Even more specifically, in moderate social constructionism, Järvensivu et al (2010) state that case studies are especially suitable in order to explore businesses and the underlying dynamics as well as they allow for a multi-dimensional view on a given context.

As Yin (2014) adds, case studies have gained popularity in social sciences over the last decades and are an especially common research tool in a lot of areas from anthropology to business management and economics, political science to education, etc. nowadays. Especially when complex (organizational) processes are looked at, case studies are a good tool to use in research (Hodkinson and Hodkinson, 2001; Verschuren, 2003; Yin, 2014), as they allow the researcher to look at a very small number, oftentimes also only one, situation(s), process(es), organization(s), etc. in detail (Easterby-Smith et al, 2012) and achieve in-depth knowledge and appreciation for the circumstances of the situation and everyone involved in the process(es) (Laws and McLeod, 2004) rather than the outcome of the endeavour (Creswell et al, 2007; Merriam, 2009).

While some authors (e.g. Stake, 2005 as cited in Creswell et al, 2007, p. 245) state that the case study approach “is not a methodology but a choice of what is to be studied”, other authors state the opposite (e.g. Merriam, 2009; Yin, 2014). Merriam (2009) and Yin (2014) both clearly argue that case studies are a research methodology in itself. Both authors explain the historical evolution of the case study approach and point out the misconception of case studies being an exploratory part of another research methodology, e.g. fieldwork, grounded theory, etc. Much rather, Yin (2014) defines the case study approach in two layers – the first being the scope of the case study, i.e. “an empirical inquiry that investigates a contemporary phenomenon (the ‘case’) in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident” (Yin, 2004, p. 16). The second layer states the features of a case study, which “copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulation fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis" (Yin, 2014, p. 17). This is supported by Merriam (2009), who states that the main focus of case research is to gain a holistic description as well as explanations, and to reveal the interaction of significant and specific factors, which are typical and characteristic of the phenomenon researched.

In comparison to the other commonly used methodologies, e.g. phenomenology, in which the main goal is to identify the essence of an experience, ethnography, in which the main aim is to identify the culture of a group within a community, narrative analysis, in which people's stories are examined in a biographical, psychological and/or linguistic analysis, grounded theory, which aims at explaining processes and actions of people undergoing transitions or changes, as well as action research, which has the goal to observe changes and their implications through action and engagement of a community (Merriam, 2009; Padgett, 2017), case study research deals with the in-depth analysis and understanding of a bounded system (Merriam, 2009). As this in-depth understanding and exploration is the core of this research, i.e. to create a consensus construction around the given subject in order to increase the competitiveness of the participants observed in the community studied, this methodology has been chosen for this research endeavour. It is highly applicable, the most suitable and thus favourable out of the multitude of options described in order for the author to successfully answer the research questions described, fulfill the research objectives identified and thereby contribute to knowledge and business practice. Due to the blurring of boundaries between the different approaches, it is also not uncommon, however, that elements of a certain methodology are added to the dominant approach, i.e. case research in this thesis, when applicable (Merriam, 2009; Padgett, 2017).

Based on this decision, the case study approach needs to be explained and outlined in more depth. According to Merriam (1988 as cited in Laws et al, 2004), the case study method is defined through four factors that secure a positive research result, namely the type of research questions, the influence on the variables involved in the process, the anticipated output as well as the definition of a case within a bounded system. Yin (2014) also states that it is essential for good case researchers to previously outline the design of the study. In order to do so, he provides five factors to create a thorough case study that add more detail to the four factors named by Merriam (1988 as cited in Laws et al, 2004). Namely, these five factors contain the research question, research propositions, the unit of analysis, the link between data and the propositions as well as strategies and procedures for data interpretation (see **Figure 27**).

Figure 27: Components of case study research design (Own figure based on Yin, 2014)

In terms of the research questions to be answered in case study research, most authors (e.g. Merriam, 2009; Henderson, 2010; Laws et al, 2004; Yin, 2014) agree that most likely how- and why-questions will build the backbone of the study in order to find out and understand how and why something (e.g. a process, a group of people, an industry, etc.) works or behaves the way it does. The research propositions, according to Yin (2014) are necessary to guide the questions in the right direction. This means that a theoretical basis and understanding of the research topic needs to be achieved before desired outputs or expectations that lead and trigger the researcher in answering the research questions can be generated. The unit of analysis describes the boundaries to the research (Merriam, 2009; Yin, 2014). It describes a single unit, which may be a single person, a group, an event, a company, a process, etc. (Creswell et al, 2007; Merriam, 2009; Yin, 2014). Boundaries in these cases can additionally be derived through time frames, the size of the group, the location or any other limiting factors that clearly mark what will be observed and what will not be observed (Merriam, 2009). Linking the data with the propositions can be achieved through various techniques, e.g. pattern matching, time-series analysis, etc. (Yin, 2014) as well as coding mechanisms (Miles et al, 2014). Interpreting the results of the case study outcomes aims at generating robust findings (Yin, 2014). According to Stake (1995), the interpretation of the results is among the most important parts of the case study. While these interpretations can be derived fairly easily in quantitative research, where the so called p-value measures whether data is statistically significant or not, in qualitative studies this will have to be achieved through identifying, addressing and invalidating as many rival descriptions for the case study results as possible (Yin, 2014).

Also, as described previously, when talking specifically about qualitative case study research, the four factors mentioned by Lincoln et al (1985), i.e. credibility, dependability, confirmability and transferability need to be taken into account in order to retrieve robust results. To the factors mentioned by Lincoln et al (1985), Easterby-Smith et al (2012) add three underlying questions that help to aim at validity, reliability and generalizability and therefore robust case study results (see **Table 3**).

Validity	Reliability	Generalizability
Have a sufficient number of perspectives been included?	Will similar observations be reached by other observers?	Is the sample sufficiently diverse to allow inferences to other contexts?

Table 3: Research design questions in constructionist research (Own table based on Easterby-Smith et al, 2012)

Furthermore and as also previously described for general qualitative research, in order to generate reliable results in case studies, it is important to rely on numerous different sources and triangulation rather than interpreting single opinions or experiences (Creswell et al, 2007; Yin, 2014). Yin (2014) states six sources and methods that can be used in case research, namely "documents, archival records, interviews, direct observation, participant-observation, and physical artefacts" (Yin, 2014, p. 106).

Additionally, according to Yin (2014), good personal preparation is of key importance before attempting a case study. First of all, the needed skills to perform a case study need to be trained. This may include preparing and learning to ask good questions, becoming a listener in order to identify the key messages, becoming flexible and adaptive, knowing the subject as much as possible and trying to avoid biases. Second of all, a protocol needs to be developed for the study, a selection of applicable cases (organization, processes, people involved, etc.) for the problem should be approached and additionally, a pilot study should be conducted in order to verify the approach, make changes to the procedure, etc.

Case study research can be carried out in numerous different ways. According to numerous authors, e.g. Easterby-Smith et al (2012), Miles et al (2014), Yin (2014) as well as Padgett (2017), there are single case studies and multiple case studies. Single case studies focus on a certain issue and try to understand and explain the issue through the defined case. In multiple case study designs, multiple cases are used to demonstrate how and why the defined issue acts the way it acts in different scenarios and settings (Stake, 1995; Yin, 2014). According to Miles et al (2014) as well as Yin (2014), it adds generalizability and the possibility for a deeper understanding to the context, i.e. helps to give interested audiences the possibility to transfer the findings into similar situations and circumstances based on more robust results.

As analysis of multiple case study methodologies is complex, Miles et al (2014) provide an overview of different strategies to generate rich content. Among others, they name case-oriented strategies, variable-oriented strategies, mixed strategies, etc. as appropriate tools to address this complexity. Yin (2014) supports the use of case-oriented strategies or cross-case synthesis, by which multiple cases essentially are compared with regards to similarities and differences in numerous defined categories.

Besides single and multiple case study designs, Stake (1995) states that a third case study model exists, namely the intrinsic case study, which focusses on developing the case itself. Yin (2014) gives further possible examples of variations in case study research. He states that purely qualitative, purely quantitative and mixed method case studies exist. This is also supported by Merriam (2009).

Regardless of the analysis approach and tools used in case study research, Yin (2014) states that high quality needs to always be assured based on four factors. Firstly, he states that this can be done by having attended to all evidence available. By this he means that the research questions and objectives have been retrieved through a thorough and in-depth literature review. Secondly, he mentions that rival interpretations need to be addressed fully, thirdly the analysis must focus on the most significant aspect of the cases without extensive analysis on less important issues, and last but not least Yin (2014) states to incorporate one's own expert knowledge into the study.

Overall, based on this approach on the one hand, it can be observed that case studies seem to have some limitations, e.g. the large amount of data produced for interpretation, the possible expenses generated throughout the research, the complexity of the case study approach in itself, the complexity of generalization while looking at a comparably small focus area, the doubts of objectivity when high researcher expertise is utilized as well as the predominant concerns about rigorousness and the ease of dismissal by people who support different ideas, etc. (e.g. Hodkinson et al, 2001; Verschuren, 2003; Easterby-Smith et al, 2012; Yin, 2014).

However, on the other hand, case study research is an especially well-suited tool when looking at complex processes (Hodkinson et al, 2001; Verschuren, 2003; Merriam, 2009). Furthermore, case studies can generate very unique results through triangulation and the use of in-depth expert knowledge, the researcher's observations and any data that might be relevant (Merriam, 2009; Yin, 2014). Hodkinson et al (2001) add onto that, that this method allows to conceptualize theories out of lived reality, it shows not only the processes, but especially the causal relationships involved in a certain situation and it incorporates unexpected findings. Easterby-Smith et al (2012) further suggest that for constructionists, the aim of showing a picture of processes and interactions of people in these processes within an organization or situation should always have a higher focus than creating a high validity for general utilization of the findings, even though this should obviously also always be tried to be achieved to the highest degree possible.

Through utilization of the case study methodology, specifically by applying multiple case study research as described in this chapter, the author feels confident to generate robust and valid data to be utilized in order to answer the research questions and fulfil the research objectives identified previously, thereby generating a contribution both to business reality as well as knowledge. Obstacles that may occur during the process have to be overcome in favour for results that aim at optimally approaching the gap in research. Good preparation, as stated before, needs to be applied therefore. This will thus be outlined in more depth and in relation to the context of this thesis in the next chapter.

3.4 Empirical research design

3.4.1 Research questions, research proposition and unit of analysis

In order to comply with Yin's (2014) remark that in a first step it is essential for good case researchers to outline the design of the study, this will be sketched in the following paragraphs, utilizing Yin's (2014) five factor model, which was previously described (see **Figure 27**). The first three factors of his model thereby look at the research questions, research proposition, and the unit of analysis.

In the author's research, the research questions have been identified through and are closely linked to the literature review, which has revealed, besides other gaps, that especially a need for more research exists with respect to understanding and improving factors affecting service technicians' response time performance in stationary equipment corrective maintenance. The adjacent questions to develop a consensus construction based on the outcomes of this study around the identified research need, which also formulates the research proposition, are displayed previously in this thesis (**Chapter 2.4**).

The four questions asked in this context are mainly how- and what-questions and therefore, according to Yin (2014), give a first hint with regards to the most relevant research methodology, i.e. case research in this case, to be used. According to the author, case research, besides the fact that it is specifically useful when complex processes need to be understood (Hodkinson et al, 2001; Verschuren, 2003; Yin, 2014), it also is especially well suited for how- and why-questions. With what-questions, it is important, in accordance to Yin (2014), to know what exactly is tried to be understood. If for instance, a what-question is aiming more in the direction of understanding how much and/or how many on a given subject, then case study research might not be the best choice, but rather surveys for instance. If more exploratory or explanatory outcomes are to be expected, i.e. what can be learned from a case study in this context, then case study research is appropriate again, however.

As the four research questions aim at finding explanations in the community studied in order to develop a consensus construction, case study research can be seen as a valid and favourable choice of methodology to answer them.

The unit of analysis, according to Yin's (2014) model is the corrective maintenance process and the service technicians in this process, the competitive objectives in this context, the perceived influence factors that have an impact on the service technician(s) with regards to the service response time performance as well as perceived improvement opportunities. In order to create an in-depth analysis of this process and its variations and similarities in different business areas, a qualitative multiple case study approach with three cases will be applied. Out of the six options mentioned by Yin (2014), the according methods for data collection in the case studies for this research have been selected to be document/data analyses, in-depth interviews as well as process observations. These have been chosen in order to include multiple viewpoints on the given context.

As it is the goal in this moderate social constructionist approach to create knowledge that is locally specific and community-based, generalization beyond the cases studied cannot be applied. However, by conducting more than one case, as Miles et al (2014) and Yin (2014) suggest, a deeper understanding can be created and a consensus for the examined cases, which provides generalization to a degree that exceeds the possibility of generalizing in one case can be achieved. The authors add that the more cases are used to create the consensus, the more robust is the baseline built for interested audiences to potentially transfer the findings to similar settings. These must be comparable, however, as suggested by Glaser et al (1967).

For the three cases, three business areas, i.e. elevator, mining equipment as well as IT hardware, have therefore been picked in order to provide a diverse range of inputs from comparable business areas in compliance with the theoretical sampling concept explained previously (Glaser et al, 1967). All these business areas have highly complex corrective maintenance processes, companies that deal with a large and diverse range of units under maintenance and large spare parts portfolios. Furthermore, as shown in **Chapter 1**, the need for servitization and highly efficient after-sales services such as spare parts logistics, maintenance, etc. as levers for companies to diversify, remain and/or become competitive, etc. in these business areas can be observed, regardless of the maturity level in servitization as well as the PSS utilized. The choice of business areas selected thereby also displays a portfolio of different average needs with regards to service response time as well as the average equipment costs involved. This has previously been displayed and explained in **Figure 2** (**Chapter 1.2.1**).

In more detail, **Table 4** gives an overview of the three cases selected for the in-depth analyses. For the elevator business area case, one of the major companies in the elevator industry is looked at. This company services capital goods priced in the multiple ten thousand Euros. A key attribute of the industry overall includes the possibility to generate high revenues through after-sales services. Furthermore, companies tend to service units that they produced as well as third-party equipment, resulting in large spare parts portfolios, and response times generally vary depending on frame contracts and urgencies. When people are locked in an elevator, one the one hand, extremely quick response times are needed for instance, but also in facilities such as hospitals, airports or production environments, a high need for units in operation is required. In residential buildings or offices with numerous units, a broken down unit can generally be compensated through additional functioning units for a limited time period on the other hand. Here, less urgency in the response time is required. These cases in this business area are generally managed through framework agreements and contracts.

For the mining equipment case, also one of the major companies in the mining equipment industry is selected for in-depth analyses. This company services capital equipment priced the range of multiple million to billion Euros. As in the elevator industry, high margins can be generated through after-sales in the mining equipment industry and also here, equipment from third-party manufacturers can be serviced in addition to own products resulting in large amounts of different spare parts in the portfolio. The need for extremely high response times in this business area results from the extremely high production losses and thus costs involved during equipment downtime.

The IT hardware case also includes in-depth analyses of one of the major companies in this business area, where products ranging between multiple ten to hundred or thousand Euros are serviced generally. This company focusses specifically on printers. As the IT business area is much more diverse than the other two, however, additional companies with different focusses are included in this case. A company focussing on servicing banking IT hardware as well as a pure service provider for IT hardware in a larger scale are included. Overall, as suggested by the intention of this thesis, only the B2B-market for stationary equipment is looked at. B2C-equipment such as home device printers or laptops, etc. is not included in this study. In this business area, just like in the other two, high margins can be generated through services in after-sales. Also here, third-party equipment can be serviced and the portfolio of spare parts is comparably large. The need for quick response times varies and is generally agreed upon in frame contracts. Generally, in production settings, where companies risk to lose revenues in large scales when equipment fails, higher needs for response times are agreed than in settings, where multiple ATMs are available at a bank in order for customers to withdraw money for example.

The respective choices for process observation venues as well as experts to be interviewed in the pilot and the main study will be in the following chapters in more depth.

	Case 1: Elevator	Case 2: Mining equipment	Case 3: IT hardware
Description	• One of the major companies in the elevator industry • Service on capital goods priced in the multiple ten thousand Euros, i.e. elevators	• One of the major companies in the mining equipment industry • Service on capital goods priced in the multiple million to billion Euros, i.e. mining equipment	• One of the major companies in the IT industry • Service on capital goods priced in the multiple ten to hundred/thousand Euros, e.g. IT hardware, especially printers • To include the variety of IT hardware available a company servicing banking IT hardware such as ATMs, etc. as well as a pure service provider especially for IT hardware were included
Key attributes	• High percentage of revenues generated from service, less from new installation • Highly complex spare parts logistics processes • Comparably large portfolio of spare parts (from screws to doors, motors, etc.) that can generally be stored and/or quickly reordered for new units and are hard to get for old units • Units under maintenance from in-house production and third party suppliers • Large variation in asked for response time from customers depending on contractual agreements • Unit downtime may cause process problems (e.g. in hospitals, airports, etc.) and reputational problems for the customers	• High percentage of revenues generated from new installation, less from service at the moment • Highly complex spare parts logistics processes • Comparably large portfolio of spare parts (from screws to crushers, etc.) with lots of customized equipment, long reorder times and high priced parts that cannot be stored for net working capital and/or size reasons • Units under maintenance from in-house production and third party suppliers • Generally very quick response times required from customers, but depending on contractual agreements • Unit downtime may cause very high production/revenue problems and reputational problems for the customers	• High percentage of revenues generated from service, less from new products (in business-to-business environment) • Usually new products are leased and revenue is generated through sales of spare parts for the products, e.g. hardware for laptops (strict product lifecycle) as well as consumables (ink for printers, etc.) • Comparably small and standardized portfolio of spare parts that can be stored and/or quickly reordered • Units under maintenance from in-house production generally, but third-party also possible • Large variation in asked for response times from customers depending on contractual agreements • Unit downtime may cause process problems (e.g. in offices, production, etc.) and reputational problems • Influence of downtime can sometimes be regulated through a comparably inexpensive second unit
Operational selection criteria	• Mid priced end-units with varying needs for response times depending on customer requirements, generally medium to high need for quick response times however • Comparably medium servitization maturity level • Different forms of PSS present in this business area • After-sales service increasingly relevant to become/remain competitive	• High priced end-units with usually very quick response times needed • Comparably low servitization maturity level • Different forms of PSS present in this business area • After-sales service increasingly relevant to become/remain competitive	• Low to mid priced end-units with varying needs for response times depending on customer requirements, generally medium need for quick response times however • Comparably high servitization maturity level • Different forms of PSS present in this business area • After-sales service increasingly relevant to become/remain competitive

Table 4: Three cases for empirical research

3.4.2 Linking data to proposition and interpreting findings

3.4.2.1 Introduction and overview

The remaining two items of Yin's (2014) five step mode (**Figure 27**) deal with linking data to the proposition and interpreting the results. Miles et al's (2014) model described in **Figure 26** is used as a guiding framework to generate according results. The empirical research phase will therefore be split into four phases that deal with Miles et al's (2014) factors, i.e. data collection, data reduction, data display as well as conclusion drawing/verification accordingly.

Phase 1 includes the preparation of the empirical research and a pilot interview to confirm the appropriateness of the research. Phase 2 is based around conducting the three case studies. These two phases aim primarily at data collection, while, as mentioned by Miles et al (2014), also data reduction and display take place in these phases through the decisions made as well as the summarization and coding/clustering. Additionally, also verifications of the approach and the results generated are included at the end of each phase.

In phase 3 the results are analyzed, interpreted and the consensus construction is developed. This includes prioritizations of the results and thus a further and final reduction of data. In phase 4, the research results are utilized to draw conclusions, show limitations, an outlook and further research recommendations. These two phases aim primarily at data reduction, data display as well as conclusion drawing. Also here, verification of the results is included. Further empirical data is not collected in these phases, however, literature is continuously screened and added to the research, where applicable. An overview of the four phases is given in **Figure 28**.

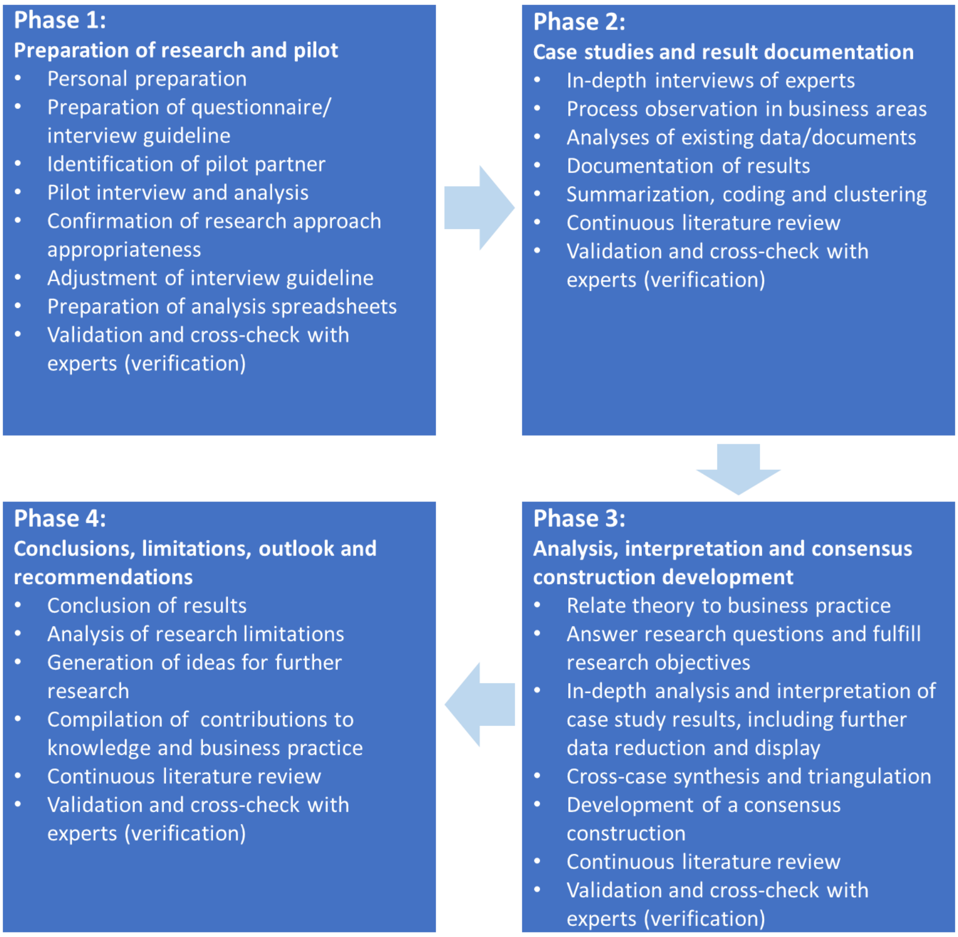


Figure 28: Empirical research phases

3.4.2.2 Preparation of research and pilot

In more detail, in accordance with Yin (2014), before the actual case studies are exercized, it is the intention of the author to confirm the appropriateness of the research within phase 1. Therefore, the results from the literature review, the research questions and research objectives as well as the proposed plan of action, the methods utilized for data collection, the interview questions as well as access to data, process observation possibilities and potential interview partners/experts are outlined and discussed with the responsible experts as part of the author's personal preparation. The experts come from different business areas and expert backgrounds, i.e. one from elevator, one from mining equipment and one from IT hardware respectively, and have been involved throughout the entire duration of this doctorate. Additionally, two university supervisors validate the preparation at this stage of the research. Further personal preparation needs, i.e. familiarizing with details of case research and particularly the methods chosen for data collection, i.e. data/document analyses, process observations and in-depth semi-structured interviews, as well as ethical guidelines, biases, soft-skills, etc. are emphasized in this phase as well. Also, as suggested by Glaser et al (1967), the author will prepare himself by familiarizing himself in depth with the area in which the research is conducted.

This phase also includes the preparation of a semi-structured interview questionnaire. The importance of interviews as a key tool to derive with new knowledge in social sciences research, according to Alshenqeeti (2014), has been recognized. By utilizing a semi-structured interview approach, according to Edwards and Holland (2013), a list of questions will be prepared that will be covered throughout the respective interviews, however, a certain degree of flexibility in how and when the questions are asked, is allowed in this concept. Furthermore, this approach allows for a dialog between the interviewee and the interviewer to emerge. Nevertheless, a clear structure should be prepared and followed and specific elements should be included (Flick, 2009; Gläser and Laudel, 2010) during preparation.

The interview questionnaire is produced in English and German in order to allow participants to choose their preferred language. Implications of language, translation and interpretation will be discussed in this context (e.g. Temple and Edwards, 2002; Temple and Young, 2004; Regmi, Naidoo and Pilkington, 2010; Berman and Tyyskä, 2011; Chidlow, Plakoyiannaki and Welch, 2014) in the respective section of the empirical analyses.

Furthermore, analyses spreadsheets are prepared and produced for the interviews, process observations as well as document/data analyses in order to document and capture the findings properly and in a way that they can be re-checked throughout the course of this research. The main target through structuring the outcomes from the very beginning, however, is to be able to derive the desired outcomes from this research and provide a structured display of the large amounts of data.

It is also seen as necessary to conduct a pilot interview at this stage of the research. Pilots, according to Gläser et al (2010) provide a tool to test approaches, methodologies, etc. in order to assure high quality outcomes for the research. Here, the largest amount of input is expected from the interview method and therefore the right questions and right structure are needed in order to generate high quality results. The questions and structure of the questionnaire additionally function as the backbone for the author during the process observations, making the pilot even more important. Adjustments to the questionnaire, its structure and questions, etc. are included in this phase as well. These will depend on the input given in the pilot.

The choice of the expert to participate as the pilot is crucial therefore. It is intended to interview an expert from one business area with comparably high amounts of expertise, experience and knowledge. Furthermore, it is seen as beneficial, if the participant has previously been involved in research endeavours before in order to also learn from his/her experience in that matter. Honest, open, critical feedback and yet strong inputs are aimed to be achieved through conducting this pilot.

Based on the outcomes of this pilot, the chosen approach to generate data through interviews, process observations as well as documents will be justified in this phase.

3.4.2.3 Case studies and result documentation

Phase 2 will deal with the three actual case studies as well as their documentation. By applying interviews, process observations and data/document analyses, it is the goal to create an overview for the author to fully understand the three business areas as well as the research proposition in the context of these business areas. With this solid knowledge baseline generated, it is then the intention to go into a detailed and in-depth understanding of the competitive objectives in this field, to understand the specific perceived influence factors affecting service technicians in corrective maintenance as well as the perceived improvement opportunities in this area. This information is needed to ultimately build a consensus construction in the community studied.

In a stepwise approach therefore, all available data from previous studies/projects as well as company internal information and documentation is considered first in each case study. Additionally, the respective markets are screened and put into context in order to relate the findings from this thesis. Further data is potentially acquired through the experts in the interviews, wherever and whenever applicable.

Secondly, process observations are conducted to gain a deeper understanding especially of the corrective maintenance processes, the circumstances and the perceived factors affecting service technicians as well as potential improvements in terms of response time. It is also the goal for the author to actually see the processes first hand in order to better understand the perspectives of the experts involved in the processes as well as to ask arising questions. For the elevator business area, findings from a previous project, in which five process observations in five different regions were executed regarding the same context, are used. For the mining equipment as well as the IT hardware business areas, one process observation each is conducted. For these venues, the author follows one/a group of highly experienced service technician(s) during their daily activities, observes the processes and asks questions regarding the context analyzed.

In a third step, in-depth semi-structured expert interviews with key employees/experts from the three business areas are carried out to build upon the knowledge from the observations and data/document analyses and to be utilized for the consensus construction.

The identification of interview partners as well as experts for the process observation venues thereby receives explicit attention in order to secure high quality inputs. All experts are carefully chosen based on their expertise, experience and knowledge. Regional differences as well as responsibilities are included and both strategic experts as well as operational experts are approached for participation. The choices of experts from the three business areas are based on the concept of purposeful sampling as described by Patton (2002). He thereby explains numerous different strategies of selecting samples, e.g. extreme sampling, intensity sampling, maximum variation, homogenous sampling, random sampling, opportunistic sampling, snowball sampling, etc. The intention of all approaches thereby is to select participants intentionally in order to derive with purposeful results for the research (Coyne, 1997). For this research, a mix between snowball sampling as well as opportunistic sampling will be applied. Snowball sampling thereby identifies experts through other experts who know that these potential participants have rich and thick information based on the research needs. Opportunistic sampling leaves the author with the flexibility to take advantage of unexpected experts being introduced or found during the course of the empirical research phase (Patton, 2002).

A very important and powerful tool to also consider in this context in order to add validity to the research results is saturation, according to numerous authors (e.g. Mason, 2010; Baker and Edwards, 2012; Fusch and Ness, 2015). The concept was first introduced by Glaser et al (1967) and states that qualitative sample sizes have to be chosen in an appropriate quantity to secure that all important points with regards to a topic have been identified (Mason, 2010). The right sample size for case studies, however, leaves a lot of room for discussion and is situation- and topic-based, according to Mason (2010), Baker et al (2012) as well as Fusch et al (2015). Fusch et al (2015), for instance, state that no one sample size fits all. Much rather, they state, that it is important to create thick data from the cases. A large amount of interviews with limited outcomes, for example, does not secure more saturation than a small amount of interviews with thick data generated. Baker et al (2012) in their work observe the same and are also supported by Mason (2010), who in his research shows that case study research exists with a range from one to 95 interviews conducted. He further explains that complete saturation can never be achieved as new data will almost always add something new. Given the fact that this may be so marginal in the overall context, however, at some point, where the vast majority of inputs have been collected, it has to be considered as arbitrary.

The author has decided to plan with 20 experts to be interviewed in addition to the process observations as well as the document/data analyses. The interviews are conducted in English or German depending on the interviewee's choices. The sampling selection has been followed by a mix of opportunistic and snowball sampling, as stated previously. For each case therefore, based on the availability of experts with the needed experience, knowledge and know-how, up to five highly experienced service technicians/supervisors and up to four (spares) logistics/ (after sales) service executives are chosen to be interviewed to gain both operational and strategic understanding. In more detail, it is intended to interview seven experts from the elevator business unit (including the pilot), nine experts from the mining equipment business area and four experts from the IT hardware business area with the necessary level of knowledge and expertise to participate. The numbers of experts chosen in the different business areas thereby mainly results from the availability of participants that match the criteria of high knowledge, experience and expertise in the context observed as well as the number of participants that granted to participate in this research within the confined time period allocated for the case studies. The comparably lower number of experts involved in the IT hardware business area will be addressed in the limitations of this research.

However, with these participants selected for the interviews, the author expects saturation based on the overall number of interviews and their focus on creating rich and thick content, the observations to be conducted as well as documents/data to be analyzed. If, however, after the cases have been conducted, the author observes that the data generated is not rich enough and saturation has not been reached, for instance when interviews still reveal major inputs that have not been identified previously with regards to the research context, further interviews and/or process observations need to be planned. This will then be discussed together with the experts involved both from the business side as well as the university side.

To conclude the data collection in phase 2, **Figure 29** shows an overview of the three parts of the result generation approach in the case studies conducted.

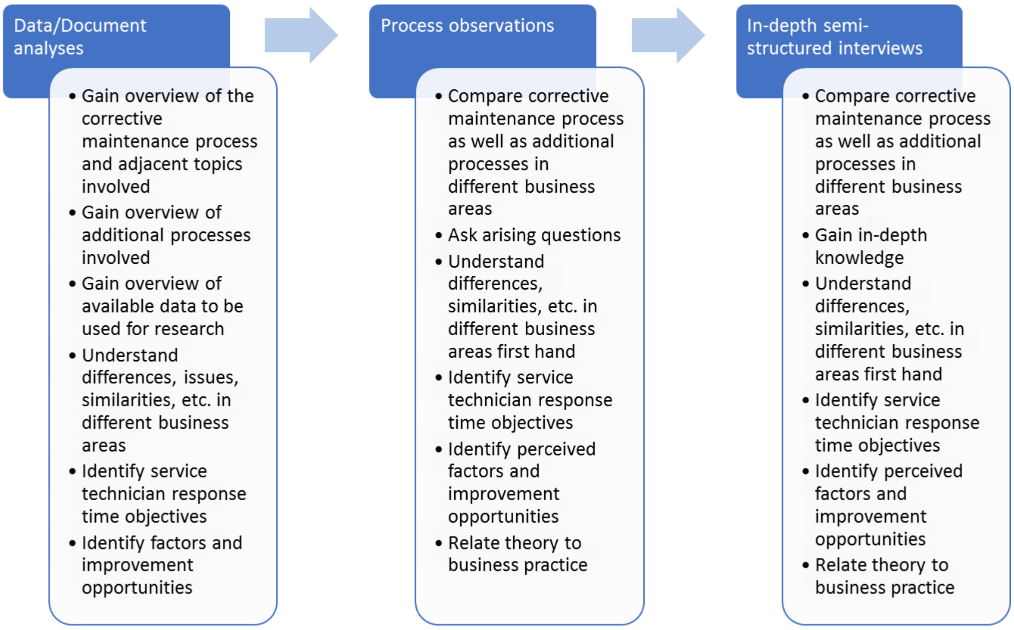


Figure 29: Steps in data collection for this thesis

To prepare for data analyses, the research results are documented throughout the entire case study. Processes are visualized and relevant data and documents are summarized and incorporated into the analyses. Interview outcomes are protocolled, transcribed and summarized in spreadsheets prepared in phase 1. Data will thereby be reduced and displayed, in accordance with Miles et al (2014), through summary tables, figures, coding as well as clustering.

By coding and clustering, as described by Miles et al (2014), the data collected can be categorized into different sections. For this research, for instance, data will be coded and clustered in order to show the applicability of the inputs to the respective research questions of this thesis. Furthermore, the corrective maintenance process will be broken down into sub-sections and inputs with respect to perceived factors that influence the service technicians in their response time performance as well as perceived optimization opportunities will be matched to one or more process steps accordingly. Also optimization opportunities will be clustered with respective factors that they might improve as well as competitive objectives with regards to service response time performance will be highlighted as such. Coding/clustering takes also place between operational as well as strategic factors and optimization potential will be marked with regards to technical assistance, back office support as well as technician enabling. Another coding level describes the business area, in which the stated points were seen as relevant.

In order to achieve this, as described by Miles et al (2014), one of the most helpful techniques is to go through the transcribed results as well as process visualizations and document summaries line by line and add codes besides the notes accordingly. The list of codes naturally grows throughout the coding process and may lead to further clustering or coding in order to condense the information. In the end of the process, however, a clear picture of which information can be utilized where in the interpretation phase as well as the consensus construction can be derived, if done properly.

The data resulting from this phase is stored in a structured database on the author's PC, allowing for logical and chronological recapitulation of events and inputs generated. Validity of the outcomes is cross-checked with the business- and university-mentors.

3.4.2.4 Analysis, interpretation and consensus construction development

Phase 3 deals with the analysis in more depth, the interpretation of the results and the consensus construction development. This builds on the analyses already conducted in the preceding phases. The main idea of this phase is to create meaning to the data collected.

For the purpose of this research methodology, i.e. multiple case study approach, cross-case synthesis, as described by Yin (2014), is applied. Each case, i.e. elevator, mining equipment as well as IT hardware will be looked at individually as described in phase 2 and the results of the three cases will then be compared to show similarities and differences as well as to draw the consensus construction between the three cases.

Triangulation of the results generated through interviews, process observations and data/document analyses, as described by various authors (e.g. Creswell et al, 2007; Della Porta et al, 2008; Flick, 2009; Bryman et al, 2011; Easterby-Smith et al, 2012; Yin, 2014), will provide robust data on the given subject based on different viewpoints. Furthermore, through triangulation of the results, according to Fusch et al (2015), a high degree of saturation can also be expected and achieved, thus contributing to valid research outcomes.

The analyses outcomes will result in further data reduction and display, as stated in the concept of Miles et al (2014). Figures and tables, etc. provide overviews and summaries of the data and results generated to be utilized for the consensus construction. The results will be displayed in a way that they link the results from the literature review and the thereof resulting framework constructed, including the research gap identified, to the results generated in the empirical research phase. Each research question and objective will be addressed and a close link between the theoretical part generated in **Chapter 1** and **Chapter 2** as well as the empirical part of this research (**Chapter 4**) will be provided.

With service technicians being a major driver in corrective maintenance response time, the overall aim of this research is to understand and improve factors affecting service technicians with respect to service response times in stationary equipment corrective maintenance and to build a consensus construction to be utilized in the community researched. Verification of the results, besides the generation of thick and robust research outcomes, will be provided by cross-checking the outcomes together with the university supervisors as well as research mentors from the three business areas involved.

3.4.2.5 Conclusions, limitations, outlook and recommendations

The final phase of the empirical research (phase 4) deals with a number of things. First of all, it is the intention to recapture and reconstruct the path towards answering the research questions and contributing to closing the gap identified in this research. This includes reflecting on the links between theory and the research results, as suggested by Miles et al (2014), as well as to draw the connections between the framework developed during the literature review and the consensus construction representing the empirical results. In this context, the three questions with regards to validity, reliability and generalizability stated by Easterby-Smith et al (2012) as well as the four factors mentioned by Lincoln et al (1985), i.e. credibility, dependability, confirmability, and transferability, are addressed.

Conclusions of the research will furthermore include an outline on the contributions made both to knowledge as well as to business practice. Additionally, an outlook and recommendations for further research are included in this final phase.

Finally, according to Marshall and Rossman (2011), every research has limitations as it can never be perfectly designed. These will be addressed in this phase as well. The limitations in this research thereby start with the boundaries outlined with regards to qualitative research (see **Chapter 3.3.2**) as well as the research methodology, i.e. case study research (see **Chapter 3.3.3**). Additionally, the moderate social constructionist position of the author and the approach chosen in this research only allows for a consensus construct, i.e. a generalization of the results in the community studied (see **Chapter 3.2**). Further research beyond this thesis is necessary, if generalization beyond the findings from this community is desired.

Furthermore, with regards to the research questions and research objectives, this thesis deals with the identification of competitive objectives with regards to corrective maintenance, perceived factors that affect the performance of the service technicians in this context as well as perceived improvement opportunities in order to derive with a consensus construction. This research does not deal with other gaps identified in the literature review (see **Chapter 2**).

Additionally, as the thesis aims at the generation of a consensus construction with regards to corrective maintenance response time for stationary equipment, other processes or fields, e.g. preventive maintenance, B2C markets, non-stationary equipment, etc. are not covered in this thesis in detail and will require additional research. Also, the selection of interviewees generates a limitation, as previously mentioned. A comparably lower number of experts from the IT hardware business area to be involved in this research has been selected compared to the other two business areas. It would have been more desirable to include the knowledge of experts from a comparable number of experts as in the elevator and mining equipment business area, however, the selection criteria, the willingness to participate in the research as well as the confined time period resulted in this selection. Therefore, it has to be stated in this context that this business area overall creates less data and a less in-depth study than the other two business areas observed.

Limitations will be addressed in more detail in the adjacent chapter of the empirical research part (**Chapter 4.4.6**). Furthermore, like all the other previous phases, also this phase is looked at and validated with the mentors and supervisors involved in this research.

It can also be stated at this point, that literature is screened continuously and added to the research throughout the entire empirical research phase, i.e. all four phases described in this chapter.

3.5 Minimizing biases

In all social research, according to authors such as Miles et al (2014) as well as Pannucci and Wilkins (2010), Fusch et al (2015) and Sarniak (2015), biases occur and cannot be avoided entirely. Biases thereby, as described by Pannucci et al (2010), are tendencies that prevent from unprejudiced reflection on a given issue, subject or question. They can occur in all phases of research, may create prejudiced research outcomes and need to be avoided to the highest possible degree (Pannucci et al, 2010; Miles et al, 2014; Fusch et al, 2015; Sarniak, 2015).

As stated by the authors (Miles et al, 2014; Fusch et al, 2015; Sarniak, 2015), biases in research can be created through the researcher, the participants or a mix of both. Sarniak (2015) in more detail explains different types of bias that can occur. For instance, she mentions acquiescence bias, social desirability bias, habituation and sponsor bias on the participant side, confirmation bias, culture bias, question-order bias, leading questions and wording bias as well as the halo effect on the researchers' side. Being aware of these and knowing what they are, as she states, is a first step towards minimizing the risks of these biases from occurring. Pannucci et al (2010) furthermore state that building a proper research design and properly following it during implementation can minimize the development of biases as well.

Additionally, as Voss, Tsikriktsis and Frohlich (2002) state, minimizing the risks on the observer/researcher can be achieved through applying multiple case studies. Miles et al (2014) add to use unobtrusive measures, providing clear definitions and explanations to the participants that cannot be misunderstood, conducting some interviews off-site, and not inflating the importance of the research issue to the participants, etc. With regards to participant biases, Voss et al (2002) point out that triangulation and the utilization of multiple viewpoints, including uncomfortable positions held by people, can be an effective means of reducing biases. Miles et al (2014) add that avoiding the elite bias by including information from all different positions within an organization, avoiding to go native, keep thinking in concepts, remain focussed on the research questions during observations and interviews, and not showing off one's own knowledge base are important in order to avoid biases on this side. They further state that it is important to have notes cross-checked by other colleagues to identify biases and, when identifying biases during an interview or observation, to understand them and to try to find out, why biases unconsciously or consciously are being used.

Being aware of the biases described in this chapter and given the research design presented in this chapter, the author feels well prepared to create research outcomes with minimized risks for biases. Biases already identified as potential issues, e.g. translation- and interpretation-related issues, limitations and their implications on biases, e.g. the different numbers of participants involved in the research per business area, as well as the possibility of experts to opt not to be recorded during interviews, etc. will be addressed throughout the empirical research, wherever appropriate.

Since the given subject represents a particularly sensitive topic with regards to objectives, influences and improvements on factors affecting service technicians' performance in service response time, however, specific attention is addressed to social desirability biases. Within the processes observed or questioned, it has to be acknowledged that individual human beings are observed, asked questions, etc. They may answer differently when they know that they are being asked for the purpose of research and may act differently compared to their normal day-to-day routine in observations. This is also known as the Hawthorne effect (Bryman et al, 2011; Porter, 2012). In order to reduce this effect as much as possible, the methods described before, e.g. clear communication and explanations about the aims and use of results from the study, and ethical issues such as privacy, consent and confidentiality are addressed and fully complied with (Schneider, n.d.). Ethical considerations will also be looked at in more depth in the following chapter.

3.6 Ethical considerations

The research in this thesis is conducted in accordance with the ethical guidelines of The University of Gloucestershire (2008), which include general responsibilities towards research participants and other researchers, informed consent, deceptive and covert research, confidentiality and anonymity as well as approval requirements. Furthermore, the ten key principles in research ethics as stated by Bryman et al (2011) as well as Easterby-Smith et al (2012), which are listed in **Table 5**, are also always considered throughout this research.

Key Principles in Research Ethics	
1.	Ensuring that no harm comes to participants.
2.	Respecting the dignity of research participants.
3.	Ensuring a fully informed consent of research participants.
4.	Protecting the privacy of research subjects.
5.	Ensuring the confidentiality of research data.
6.	Protecting the anonymity of individuals or organizations.
7.	Avoiding deception about the nature or aims of the research.
8.	Declaration of affiliations, funding sources and conflicts of interest.
9.	Honesty and transparency in communicating about the research.
10.	Avoidance of any misleading or false reporting or research findings.

Table 5: Key principles in research ethics (Own table based on Easterby-Smith et al, 2012)

In order to be able to conduct the research as a full-time employee at a multinational enterprise, it was necessary for the author to receive approval for the research through senior management of the author's employer. Before applying at The University of Gloucestershire, the research proposal was therefore discussed with the relevant executives and approval was received. It was agreed that further approvals are to be discussed with direct superiors throughout the research endeavour. Regular meetings and an information flow are implemented and further approvals are therefore obtained prior to the respective submission.

In addition to that, three experts, one from each business area, are consulted and informed throughout the entire empirical research process. In the course of the four phases described in this chapter, the interview guidelines, interview partners, process observations, data accessibility, the consolidation of the case study outcomes as well as the derived consensus construction and conclusions, etc. are presented to them and validated for applicability and correspondence to the ethical guidelines.

A very important ethical consideration with high awareness need that was discussed as one of the starting points for this research is the fact that in optimization and change projects, careful management and a focus on process improvements rather than people optimization needs to be achieved in order to generate the desired outcomes that are supported by everybody involved. With a focus on the processes, people dealing with the processes are likelier to support the change and give inputs in order to improve. Social desirability biases may therefore be reduced and minimized. With a focus on people, much higher resistance to change would have to be expected. It is therefore assured and communicated at all times throughout the research process that the focus of this thesis is on eliminating process issues and thus supporting the people in the respective processes.

Furthermore, it was discussed with the supervisors of this research that a data base is created on the PC of the author. It has been agreed that all relevant data can be stored in this database throughout the research endeavour. This database is accessible only to the author and no other person at all times. Only processed and neutralized information has been agreed to be discussed with supervisors and mentors or other experts.

Besides the general ethical issues discussed, especially in the empirical part of the thesis, further ethical considerations need to be taken. For both process observations as well as interviews, the selected participants are approached well in advance of the actual interview or process observation. The general rule of thumb is to approach the interviewees or experts for process observations approximately four weeks in advance. This time may vary, however, due to availability reasons. Nonetheless, it is the aim to contact participants as far in advance as possible and to always have at least a few days in between the initial contact, which is generally through phone or email as well as personal approaches, and the interview/process observation itself.

The participants in this initial contact are informed about the purpose of the research, that their participation is requested and that approvals for the research and the data collection have been received from executive and senior management previously. Relevant documents, questions, etc. are sent to them in advance and they are given the opportunity to ask questions and seek clarifications prior to the interview/process observation. Also they are given the choice to receive the information and have the interview/process observation conducted in English or German. Refusal of participation is accepted without reasoning at all times and at any point within the process. It is stated that other participants will then be approached instead. The participants are furthermore informed that information resulting from the cases is handled confidentially and only stored on the PC of the author for the research purpose. The participants are also informed that results from the study might be published and they are given the opportunity to review/approve their statements recorded and the notes taken by the author. It is also stated that personal and company specific information is treated in strict confidence and is to be destroyed after completion of the PhD program. Specifically for the interviews, prior to the actual conversation, each participant is asked for permission to record the interview. Also here, refusal is accepted without reasoning. Data collected in the first section of the interview guideline, i.e. outline and circumstances, which includes the names and personal information of the interviewees, is never recorded or mentioned in any case. It is stated to the interviewees that it is solely needed for the author to refer back to statements and context made by specific experts. Only job titles and business areas as well as the number of years of business experience are agreed to be mentioned in the context of the analyses in this thesis.

Further ethical issues may be discovered during the pilot interview, which is conducted in the same fashion as all the other interviews. The only additional part in this interview is that feedback and analyses between the interviewee and the interviewer will be conducted. Through this, it may become clear that further information is needed to be given to the interviewees prior to the interview in order to better gain a more detailed understanding of the context. Also, potentially parts may be decided to be changed entirely or to be moved around in order to create a better information transfer and higher involvement of the interviewee. All discoveries that may provide a better context for the participants will be adjusted for the rest of the interviews immediately. As the questionnaire developed is utilized as the guiding tool for the process observations as well, the changes will apply for this method of the study as well.

In terms of document/data analyses, the people approached for specific data and/or documents are informed about the background of the project, the purpose and goal of the research, the approval given by the executives and senior managers as well as the need to support this research through available data. Furthermore, also here, the experts and data holders are informed that the information provided is handled strictly confidentially and only for the purpose of this research. They are also informed that all sensitive information, i.e. company name or names of people involved in data collection, are to be neutralized and not mentioned. When experts are approached for specific documents during interviews or process observations, this applies as well.

Overall, the moderate social constructionist approach applied in this research suggests accepting multiple different viewpoints as stated by numerous authors (e.g. Guba et al, 1994; Järvensivu et al, 2010; Easterby-Smith et al, 2012). In accordance with this approach, statements made during the empirical research, i.e. interviews, process observations and data/document acquiring are accepted, noted down and further questions for clarification are asked whenever appropriate. If biases become obvious to the author, the reasoning behind these is tried to be understood. Questions are never asked, however, to change somebodies viewpoint, e.g. to persuade an interviewee with an operational background from strategic advantages of certain points and vice versa, for instance. Contrarily, besides similarities, exactly those differences in viewpoints between operational and strategic employees, experts from different business areas, within the same business area, different geographical backgrounds or participants with different levels of experiences are searched for. The choice of experts for the empirical research phase has been made accordingly. The diversity in information generated is seen as the backbone to build a consensus construction in the community studied to fully understand and improve factors affecting service technicians' performance with regards to stationary equipment corrective maintenance response time.

Throughout the empirical research phase, ethical considerations mentioned in this chapter will be highlighted and addressed again, whenever necessary.

3.7 Intermediate conclusion

To conclude, this chapter outlines the research philosophy and research methodology of the author in order to answer the research questions, fulfill the research objectives and thus contribute both to knowledge as well as business practice. A detailed overview of the content to consider in order to derive with valid and robust knowledge is given in **Figure 30**.

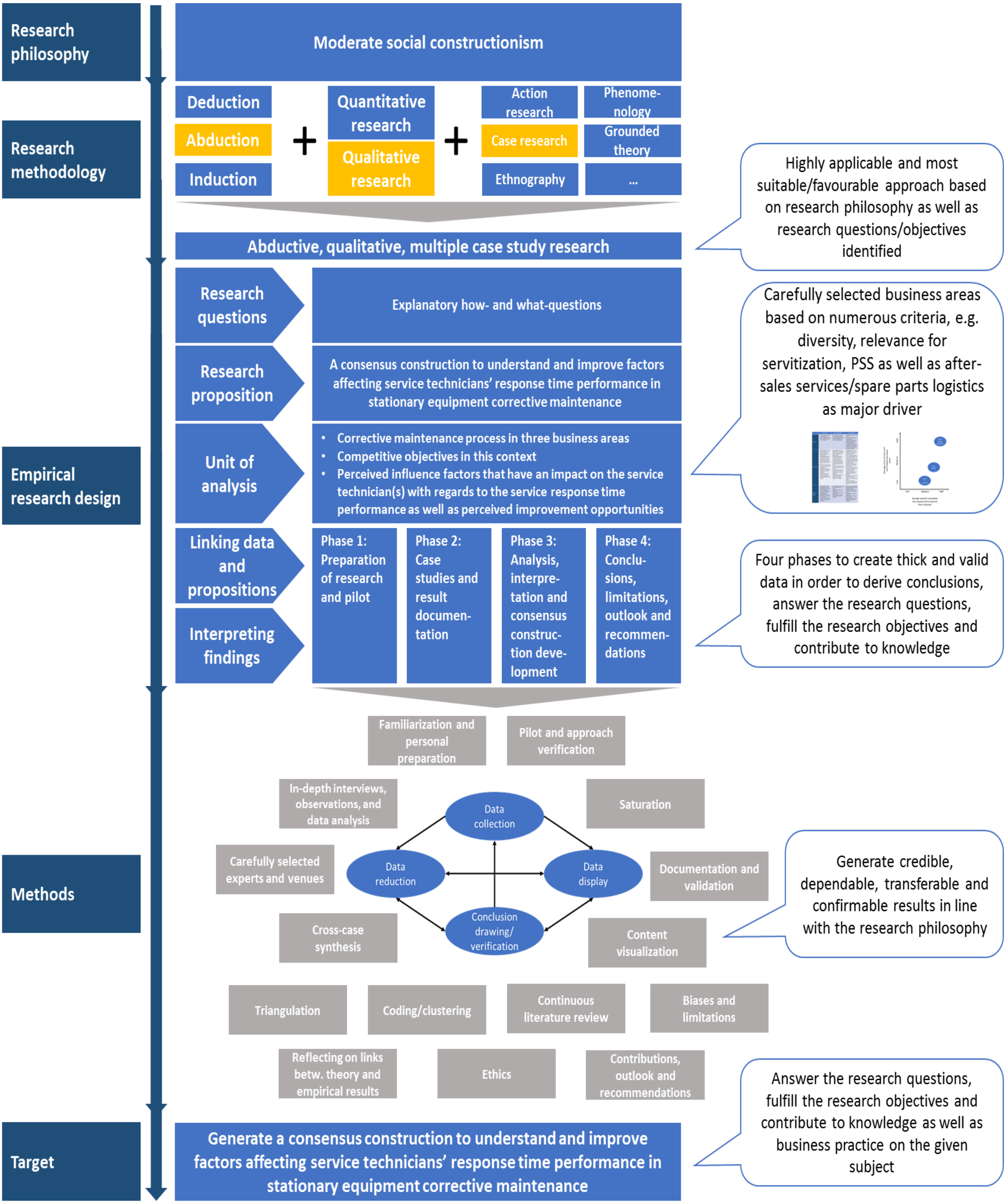


Figure 30: Reconstruction of research approach to answer research questions and fulfill research objectives

In summary, the author follows a moderate social constructionist research philosophy and applies an abductive, qualitative, multiple case study approach in this research. The research design is built around Yin's (2014) five factor model, which describes the type of research questions asked and their relation to the identified gap in literature, the research proposition as well as the unit of analysis. Furthermore, this model describes the process of linking the data to the propositions as well as interpreting the findings.

The according research design is outlined to comprise four phases, which will be applied by the author. The first phase looks at the preparation of the research as well as conducting a pilot to confirm the appropriateness of the approach followed by conducting and documenting the actual case studies in a second step. In the third phase, the in-depth analysis, interpretation and consensus construction development will be worked on, before in the final and fourth step conclusions are drawn, limitations and outlook as well as recommendations are given.

In these four phases, a large amount of concepts will be applied to ensure data collection, data reduction, data display and conclusion drawing/verification are applied in a way that credible, dependable, transferable and confirmable results will be generated in line with the research philosophy. Examples that will be explained in this context include coding/clustering, triangulation, cross-case synthesis, etc. Utilizing the outlined concept for the empirical part aims at generating a consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance, thereby connecting back to the identified gap in literature described in **Chapter 2**.

4 Empirical research[3]

4.1 Phase 1: Preparation of research and pilot

4.1.1 Introduction

As displayed in **Figure 28** and introduced in **Chapter 3.4.2.2**, in phase 1 of the empirical research, a number of goals were aimed to be achieved. These included personal preparation of the author in numerous ways, the identification of a pilot partner, the preparation of an interview questionnaire/interview guideline, conducting the pilot interview, analyzing the outcomes, confirming the research approach appropriateness, making adjustments to the interview guidelines, the preparation of analysis spreadsheets, and finally the validation and cross-check with experts for verification.

This chapter is therefore clustered in numerous different sub-chapters. Personal preparation will be described, before methodological preparations are explained. In a third step, the preparation of the pilot will be discussed. This is followed by the actual results of the pilot, the methodological impact of the pilot results and finally the confirmation of the appropriateness of the author's choice for the approach displayed.

4.1.2 Personal preparation

Personal preparation of the author included three major different steps. First of all in this phase, it was the intention of the author to assure the necessary skills needed to conduct case studies with regards to the research endeavour are given. This, as stated by Glaser et al (1967), starts by familiarizing with the area of research. Having conducted an in-depth literature review that resulted in numerous research questions and objectives (**Chapter 2**), as well as carefully identifying three applicable cases to contribute to closing the gap in knowledge (**Chapter 1** and **Chapter 3**), the author felt that he is very familiar with the topic and research area prior to the empirical research phase. Furthermore, parts of his professional career, the author has worked in spare parts logistics optimization, also assuring and adding to the solid background in this topic.

Additionally, it was important for the author in this phase to familiarize with the methodology and methods utilized, according to Yin (2014). For this research, case studies have been conducted. The methods utilized for the case studies were interviews, process observations and data/document analyses accordingly. A thorough understanding around these choices has been generated as explained and displayed in **Chapter 3**. Achieving the necessary skills to conduct case study research thereby, according to Yin (2014), includes preparing and learning

[3] All information displayed in this chapter (**Chapter 4**) has been retrieved and generated through the empirical case study research (interviews, process observations and data/document analysis) unless otherwise indicated.

to ask good questions, becoming a listener in order to identify the key messages, becoming flexible and adaptive, being aware of limitations, ethics and trying to avoid biases.

Being aware of these factors is an important start to internalize these necessities. Additionally, know-how from managing projects and talking to executives regularly helped the author to prepare for the interviews, feeling comfortable to talk to superiors or very experienced experts in their field of business. As the author additionally conducts and also coaches numerous process optimization projects in various business scenarios and departments within his day-to-day business, especially with the Six Sigma methodology, he knows that asking the right questions and listening carefully is of major importance to generate successful project outcomes. Usually, the project teams for these process optimization projects consist of experts from fields that are unknown or not well known to the author. In order to successfully optimize a process, it is therefore essential to ask good questions, listen carefully to the information that comes from the experts, read between the lines to get the information needed and generate solutions. Also this project execution approach has given the author the necessary skills to triangulate knowledge from experts as well as process observations and available data.

These experiences and practical knowledge are especially valuable, as Gläser et al (2010) point out that the art of interviewing, asking the right questions, as well as spontaneously and flexibility interacting with the interviewee or the expert in a process observation can never fully be transferred through method books, but has to be learned through experience. For theoretical preparation on case studies, however, a solid theoretical baseline is important nonetheless. Accordingly, books and papers have been read throughout the course of the preparatory work. Key literature that has especially helped the author included Flick (2009), Bryman et al (2011), Easterby-Smith et al (2012), Miles et al (2014) and Yin (2014) on case study research and interviews as well as Gläser et al (2010) and Edwards et al (2013) more in-depth on interviews. As explained before, the specific additional preparatory focus on interview literature supplementing general case study research, which includes document/data analysis as well as observations, thereby relates to the importance of interviews generally in qualitative research (Alshenqeeti, 2014) and in this research in particular as this method was expected to provide the majority of outcomes for this thesis. In addition, the preparatory steps needed for interviews conducted were seen as beneficial for the process observations as well.

A comprehensive preparatory overview of skills particularly important in interviews is provided by Bryman et al (2011). This is displayed in **Table 6**.

#	Criteria	Explanation
1	Knowledgeable	Interviewer is thoroughly familiar with the focus on the interview.
2	Structuring	Interviewer gives purpose for interview, rounds it off, asks whether interviewee has questions.
3	Clear	Interviewer asks simple, easy, short questions and does not use jargon.
4	Gentle	Interviewer lets people finish, gives them time to think, tolerates pauses.
5	Sensitive	Interviewer listens attentively to what is said and how it is said. Interviewer is empathetic in dealing with the interviewee.
6	Open	Interviewer responds to what is important to interviewee and is flexible.
7	Steering	Interviewer knows what he or she wants to find out.
8	Critical	Interviewer is prepared to challenge what is said – for example, dealing with inconsistencies in interviewee's replies.
9	Remembering	Interviewer relates what is said to what has previously been said.
10	Interpreting	Interviewer clarifies and extends meanings of interviewees' statements but without imposing meaning on them.
11	Balanced	Interviewer does not talk to much, which may make the interviewee passive, and does not talk too little, which may result in the interviewee feeling he or she is not talking along the right lines.
12	Ethically sensitive	Interviewer is sensitive to the ethical dimension of interviewing, ensuring the interviewee appreciates what the research is about, its purposes, and that answers will be treated confidentially.

Table 6: Criteria of a successful interviewer (Own table based on Bryman et al, 2011)

In addition to the day-to-day business and the projects conducted or coached as well as building up theoretical knowledge through literature, workshops and trainings, such as on leading interdisciplinary teams, interviewing, sense of self versus awareness of others, etc. have been visited in order to be prepared for this research. Also, the author has taken part in a doctoral program provided by the author's employer. Here, throughout the course of each year, additional workshops and get-togethers with fellow researchers were organized to discuss issues, critically reflect upon the research endeavour and prepare oneself for the empirical research phase.

The second step in the author's personal preparation was to explore and create an understanding on the ethics for this research, as well as familiarizing with limitations and biases. These points were taken very seriously. Biases (**Chapter 3.5**) and ethics (**Chapter 3.6**) were covered in-depth with regards to this research and will be highlighted whenever needed throughout the empirical research phase. Limitations have also been considered as part of the preparatory work by the author (**Chapter 3.4.2.5**), but receive further dedication in the respective research phase (**Chapter 4.4.6**), when the research outcomes have been presented and a full picture can be shown.

The third major step in personal preparation was to create a reconfirmation for the research itself. As highlighted in the context of ethics (**Chapter 3.6**), it was necessary in the course of the preparation for this research to involve numerous experts and to receive approval for the research to be conducted. Therefore, the results from the literature review, the according gap in knowledge as well as the research questions and research objectives were outlined and presented to the three experts from the elevator business area, mining equipment business area as well as the IT hardware business area to validate the context for the business areas involved and to receive their approval. Additionally, the research design to conduct the empirical research was also approved by the experts in this phase. Here, particularly for the empirical research phase, the experts were informed that they were to be involved after each of the four phases as displayed in **Figure 28**, provided with the outcomes and involved in discussions around validation and cross-checking in order to derive verification. The two university supervisors were involved in this process as well.

4.1.3 Methodological preparation

Besides personal preparation, this phase also included the preparation of a semi-structured interview guideline. This guideline was utilized as the backbone structure for both interviews as well as process observations. The semi-structured interview approach, as suggested by numerous authors, e.g. Flick (2009), Gläser et al (2010), Bryman et al (2011) and Edwards et al (2013), thereby provides the researcher with a list of questions on a set of specific topics to be covered and researched. However, this approach provides the freedom of flexibility. This means that the researcher does not need to follow a strict order of asking questions, can move into depth on a certain aspect whenever necessary, ask additional questions, etc. In total nonetheless, as suggested by Bryman et al (2011), the majority of questions will have been asked, potentially sometimes varying slightly in wording or order, to all interviewees or experts observed during the case study process. One of the major advantages of this approach, according to Edwards et al (2013) in this concept is, that an atmosphere of interactional exchange of information respectively a dialog rather than an interview can be created.

In order to prepare the respective interview guideline, Bryman et al (2011) state a number of criteria that should be adhered to. For instance, they state that an order for the topics covered should be ensured in order to create a discussion flow and a red thread throughout the interview. Interview questions, according to them, should not be too specific, but should obviously be formulated in a way that they support answering the research questions. The questions should furthermore be easy to understand and they should not be leading the interviewee to answer in a specific way. Questions to be included in the guideline, according to Bryman et al (2011) as well as Gläser et al (2010), should also show various types of questions in order to generate an in-depth understanding. Questions thereby should range between introductory questions, follow-up questions, probing questions, specifying questions, direct and indirect questions, structuring questions, and interpreting questions, etc.

Additionally, Bryman et al (2011) suggest to ask general information upfront the interview in order to contextualize the information provided. Gläser et al (2010) support this by stating that the interviews should never start with the first question, but rather an introductory part that clarifies topics such as familiarization between interviewer and interviewee, the research objectives, structure of the interview, ethical components such as information and data treatment, anonymous and neutralized display of data, etc. Also, in this first part, according to the authors, it is important to ask for permission to record the interview. Additionally, here, notes can be taken with respect to the location, where the interview was conducted (Bryman et al, 2011).

In this research, a threefold research guideline has therefore been developed for the interviews as well as the process observations that is in line with the constructs and suggestions in literature (e.g. Gläser et al, 2010; Bryman et al, 2011). The three parts thereby are formed by the outline and circumstances of the interview, the pre-interview, and the interview itself.

The first part, i.e. outline and circumstances, provide the cover sheet for the interview, which again states the thesis title, the content of the pre-interview and interview, the interview method and the name of the interviewer. Furthermore, here, information with regards to the interviewee, i.e. name, position and company, is aimed to be included as well as the date and length of the interview, the location and also supporting material utilized. Additionally here, it is noted whether or not the interviewee gave permission for the interview to be recorded. In this context it has to be mentioned that literature clearly suggests to record all interviews, if possible, in order to assure that all information can be captured for the analysis (e.g. Flick, 2009; Gläser et al, 2010; Bryman et al, 2011). However, in accordance with the ethical guidelines, interviewees were given the possibility to opt out on being recorded without questioning. For these cases, it was agreed between the interviewer and the interviewee that more time was allowed for taking notes in much more depth and protocol form in order to assure that all information was received. It was also agreed for interviewees to double check the notes in the days following the interview in order to add further notes that were perceived to be missing.

The information provided in this chapter, i.e. outline and circumstances, was aimed to be filled in the according sections by the author/interviewer in the preparatory stages of the interview, e.g. after having initial contact with the interviewee, as well as after the interview, e.g. length of the interview, recording, etc. The information provided in this chapter has only been used to contextualize and reference information provided in accordance with the agreed format of neutralized and anonymized data display. It was not part of the actual interview.

An overview of this part of the interview guideline is displayed in **Figure 31**.

INTERVIEW GUIDELINE

A consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance

INTERVIEW PARTNER	Name:	______________
	Position:	______________
	Company:	______________

CONTENT

Pre-Interview
Introduction and welcome
Short introduction of interviewer
Short introduction of interviewee
Short introduction of topic
Structure
Confidentiality explanation

Interview
General information
Corrective maintenance process
Influencing factors
Performance improvement

INTERVIEW METHOD Semi-structured personal interviews, supported by interview guideline and auxiliary material (interview guideline, voice recorder, timer, pen and paper)

INTERVIEWER Florian Lotte

1

DATE ______________

LENGTH
Start: ______________
Stop: ______________
Length: ______________

RECORDING
□ yes
□ no

LOCATION
□ Jobsite
□ Other ______________

SUPPORTING MATERIAL
□ Interview guideline
□ Voice recorder
□ Timer
□ Pen and paper
□ Other ______________

2

Figure 31: Outline and circumstances of the interview

The second part of the interview guideline, i.e. pre-interview, provides the introductory section of the interview as suggested by Gläser et al (2010) as well as Bryman et al (2011). Here, it was the intention to create a comfortable atmosphere for the interview in line with the ethical guidelines, clarify necessities and questions and introduce the context of the interview. The starting point in this section is geared to provide an introduction and welcome, in which the interviewer has the opportunity to thank the interviewee or process observation expert for participation. Additionally, here it is clarified whether or not recording is allowed. This section is followed by a short introduction of the interviewer and a short introduction of the interviewee, before the interviewer outlines the topic in more depth and detail. The structure of the interview, which has been clustered in four sections, i.e. general information, corrective maintenance process, influencing factors, performance improvement, is explained and followed by confidentiality statements of the interviewer. Here, points such as data treatment and storage, neutralization and anonymity of informants is explained and ensured.

To provide a clear structure for the interview guideline thereby, it has been organized in four columns. The first column states the topic, the second a consecutive numbering, the third states the focus area and the fourth column provides bullet points and comments on details to be included as well as questions to be asked in the respective sections. An example of this structure can be seen in **Figure 32**.

PRE-INTERVIEW

TOPIC		FOCUS AREA	DETAILLED POINTS/COMMENTS
Introduction	0.1	Introduction and welcome	• Welcome and thank you for participation • Possibility of recording the interview
Interviewer	0.2	Short introduction of interviewer	• Name • Project Manager (focus on process optimization) • Doctoral candidate at University of Gloucestershire, UK • Prior studies in business management and international business with one focus area being in logistics • Approx. four years of experience in spare parts logistics projects; approx. 1.5 years project management
Interviewee	0.3	Short introduction of interviewee	• Name • Company • Business area • Number of employees in company • Registered office • Sex • Position/actual job description • Length of affiliation with the company/position • Education • Prior experiences with relevance to spare parts logistics/process optimization (examples and in years)
Topic	0.4	Short introduction to the topic	• Short description by mail/phone prior to interview • Expert interviews with approx. experts (operational and strategic) in three business areas, possibly also customers • Process: Call for maintenance – repair of unit (corrective maintenance) • Central questions: What are the key competitive objectives in corrective maintenance, perceived influence factors on the service

3

Figure 32: Example extract of the structure of pre-interview

For the interview itself, which followed this introductory section and which aimed to provide the content to answer the research questions and fulfil the research objective, the same columns as in the pre-interview section were utilized to assure a common structure and red thread. Here, only the focus area was exchanged for guiding or main questions with regards to the respective topic. The interview section, which forms the main body of the interview has thereby been organized in the four clusters described previously, i.e. general information, corrective maintenance process, influencing factors, performance improvement. The section on general information aims at providing context to the topic of spare parts logistics, corrective maintenance as well as industry and company specifics. The section on the corrective maintenance process aims at generating data with regards to the different process steps, the role of response time as well as other competitive factors/objectives and understanding structures and break-downs in more detail. The third section focusses on perceived factors that influence the performance of service technicians in corrective maintenance response time and the fourth section focusses on perceived improvement opportunities respectively.

Furthermore, perceived ratings on the importance and influence (from very high to very low) of certain factors, improvement opportunities as well as general process steps, etc. were included in all parts of the questionnaire. An example of the structure used for the interviews is displayed in **Figure 33**.

INTERVIEW

TOPIC		MAIN QUESTIONS	DETAILLED POINTS/COMMENTS
General information	1.1	How important is spare parts logistics in general for your company?	• How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • What is the approx. share between service and new installation in revenue? • Please rate the importance of spare parts logistics for your organization on a scale from very low, low, medium, high, very high
	1.2	How important is corrective maintenance in spare parts logistics in your company?	• How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • How often is corrective maintenance required? • When does corrective maintenance play an especially important role? • Please rate the importance of the focus on corrective maintenance for your organization on a scale from very low, low, medium, high, very high
	1.3	Please explain the context of your spare parts logistics corrective maintenance business.	• Number of different spare parts items in portfolio • Price range of average parts • Size and weight of average parts • Density and organization of spare parts logistics network • Number of service/spare parts related employees in organization • Number of service technicians in organization • Corrective maintenance only on own units or also on competitor units • Why are quick service response times required by customers? • Downtime costs per unit • Other than financial cost due to downtime • Other important information
Corrective maintenance process	2.1	How does the spare parts corrective maintenance process look like in your everyday work?	• Please explain the process steps from call for corrective maintenance to repair of unit in its steps. Please highlight the main stages.

5

Figure 33: Example extract of the structure of interview

As explained before, this guideline was intended to be used as a structure and backbone for the interview to assure all necessary information was retrieved. Not every question was asked in the order it was written down in the guideline, however. Additionally, further questions were included wherever needed, and topics were skipped at some point and referred back to later, whenever applicable. A full version of the final interview guideline in English can be found in **Appendix 1**.

For the empirical research process, the interview guideline was produced both in English as well as German in order to allow participants to choose the language. Here, the implications of language, translation and interpretation have to be mentioned and discussed. Temple et al (2002) state that language is a very important part of conceptualization and can define similarities and differences among different cultures. The words that are used in language are thereby highly important, as they can mean different things to different people. While this can happen for different groups or people using the same language, it is especially important in cross-language research (Regmi et al, 2010). Temple et al (2002) further state that the role of a translator and interpreter is therefore a key to transfer meaning.

Crystal (1991) as stated in Regmi et al (2010, p.17) defines translation as the process in which "the meaning and expression in one language (source) is tuned with the meaning of another (target) whether the medium is spoken, written or signed."

According to Temple et al (2002), the dilemma in translation and interpretation in social sciences suggests that there is not a single perfect translation. Much rather, translating can result in a large variety of possible word combinations that may result in different meanings that are interpreted differently. Based on this, the authors state that it is important to move away from literal word for word translation to create meaning and instead focus on the meaning of what is being discussed and said, i.e. interpretation. They further state that it is important to know that concepts are being explored and the context is the most important part in deciding on the similarities or differences in meaning.

Temple et al (2004) in their paper emphasize the possibility of biases arising through translation. However, they also reemphasize the fact that whilst a perfect translation does not exist, reconstructing the value of what has been discussed rather than finding a cultural inscription through translation has been recognized to allow translation and interpretation to generate valuable meaning. Furthermore, they add that translating and interpreting can be accomplished by oneself in order to avoid adding another interface with an external translator/interpreter. Also, they state that researchers, who are fluent in multiple languages should not shy away from using this opportunity to include cross-cultural/-language inputs for the research.

Regmi et al (2010) provide five commonly used steps to further ensure a minimization of biases through translation and interpretation. They state, that it is important to determine the relevance or context, before forward translation is conducted. This is then followed by backward translation, as well as an examination of the translated meaning in both the source and target language. In a final step, the entire process should be revisited to derive with similar interpretations. This approach will therefore be applied in this research, whenever translation and interpretation are required due to interviews being conducted in German.

Regardless of the language used in the interviews, process observations as well as the documents/data analyzed, a structure to handle the large amount of data and information expected was prepared in this stage of the empirical research.

First and foremost, the author in this stage planned to take field notes during every interview and process observation. This, as suggested by Flick (2009) was intended to be done during the actual venues. Right after the interviews and process observations, it was planned for these notes to be double checked and points were to be added, if applicable. For notes taking, documentation sheets were prepared, as suggested by Flick (2009). Here, the sheets included the structure of the interview guideline with gaps for each of the questions, in order to quickly add content to the respective questions during the process observations as well as interviews (see **Appendix 2**). Furthermore, blank sheets of paper were added in order to be utilized when additional information was mentioned or information with regards to a specific question was exceeding the space provided.

For interviews that could not be recorded, as stated previously, an in-depth protocol was planned to be generated during the interviews. All recorded interviews were planned to be transcribed, as suggested by numerous authors (e.g. Flick, 2009; Gläser et al, 2010; Bryman et al, 2011).

Transcription, according to Bryman et al (2011) is beneficial to the research as it allows a thorough an in-depth analysis of what has been said, it corrects natural limitations of the researchers memory, it permits multiple examinations of what answers, and it opens data to public scrutiny testing, thus also minimizing biases.

According to Flick (2009), different transcription systems are available. For sociological research he emphasizes to take into account a number of factors in order to determine the transcription system. The importance in this system is to assure manageability for the transcriber, readability, learnability as well as interpretability for the analyst. Furthermore, he states that elements such as turn taking, breaks, ends of sentences, etc. need to become clear and anonymity needs to be a central objective. Gläser et al (2010) add that standard orthography should be used, and non-verbal statements, e.g. smiling, coughing as well as pausing, etc. should be added when they have a meaning to the context. Additionally, underlining, as stated by Flick (2009), emphasizes statements and bracketing words or sentences show uncertain transcriptions (Flick, 2009; Gläser et al, 2010).

These transcripts as well as the in-depth protocols form the baseline for analyses of data. Triangulation with the results from note taking and protocols of process observations, protocols of interviews that were not recorded, as well as document analyses was planned to create thick and robust outcomes (Yin, 2014). Coding and clustering, as suggested by Flick (2009) as well as Miles et al (2014) was planned to be applied. As described previously, based on the results generated through these methods, data reduction, data display, and conclusion drawing/verification was planned to be achieved (Miles et al, 2014).

In order to document and structure this data, Microsoft Excel sheets as well as Microsoft Word files were prepared and produced in order to capture everything efficiently and effectively, summarize and reduce data, visualize findings, and to build a thorough baseline for analysis.

These documents were also intended to create a structure in order for the information generated through the empirical research to be re-checked, if necessary. In this context, furthermore, a structured data base was developed on the author's PC to store the data that was generated throughout the research. This was necessary in order to not lose the overview of the large number of data that was generated from the various sources, to secure the possibility to re-capture the events in a chronological fashion and to quickly access needed data whenever required. This was intended to be valuable both for individual use as well as for validation and cross-checking with experts for verification purposes. An overview of the database can be found in **Appendix 3**.

Another important factor in the methodological preparation was the choice of experts for interviews and venues for observations, as well as accessibility of data and documents. Discussions were initialized in this phase based on the selected strategies of snowball sampling and opportunistic sampling as suggested by Patton (2002). The final choice of experts selected for the research will be discussed in more depth in **Chapter 4.2**.

4.1.4 Pilot preparation

Having built a strong baseline through personal as well as methodological preparation, a pilot was intended to be conducted in this phase as well.

As stated before, the focus thereby was on the semi-structured interview as the guideline was aimed to be utilized as the backbone for interviews and process observations. In this case therefore, the aim of the pilot was both to check, if the interview guideline generates the required information needed and also, if additional questions, issues or other amendments are needed to be included in order to optimally conduct the interviews in the empirical research phase. The idea thereby, as suggested by Bryman et al (2011) is to use the pilot interview to question the initial version of the guideline and create a final version for further utilization based on the generated results.

As the choice of expert is highly important, as displayed previously, for the semi-structured pilot interview, a senior expert from the elevator business area was selected. This expert was very well known to the author prior to the research. He was chosen due to his high expertise, knowledge and know-how in the field of spare parts logistics. Additionally he was involved as an expert and interviewee in other doctoral research studies beforehand. His expert knowledge, his prior experience with interviews as well as the good personal relationship between this expert and the author were seen as highly valuable factors to conduct the pilot interview with. The goal of this choice was to execute the first interview in a relaxed, yet real scenario atmosphere, but mostly to receive open and critical feedback, questioning of the guideline and to receive further feedback and advice for the rest of the interviews as well as observations.

According to the ethical guidelines and just as planned for all interviews and observations, the pilot interviewee was approached approximately four weeks prior to the interview. As this expert was well known to the author, he was approached in person. A quick introduction of the topic was given in this context and the reasoning for the study was explained. Also, here it was stressed that all information was to be handled strictly confidentially and all personal and company specific information was to be neutralized and anonymized. Furthermore it was communicated that refusal to participate was accepted without reasoning at any point of the process. As the pilot candidate agreed to participate, he was then given the according interview guideline by e-mail in order to familiarize himself with the topic and ask arising questions prior to the interview, if required.

The pilot interview itself was planned to be conducted as a real case interview. Discussions for amendments and a general analysis with the expert were planned to be done afterwards. This aimed at allowing the approach of using a semi-structured interview guideline as the method of conduct to be verified especially for the interviews, but also for the observations.

After the interview, the pilot interviewee was given the opportunity to review both the recordings as well as the interview notes from the author, and was asked to make adjustments or cancel statements, if necessary. The approach described was adapted for all further interviews as well.

Based on the pilot interview results, which are displayed in **Chapter 4.1.5**, the methodological impact on the guideline is aimed to be discussed (**Chapter 4.1.6**). Finally, based on the pilot, it was the intention to reconfirm the research methodology and approach. The results from the pilot have therefore been used to double check their appropriateness to generate results that contribute to answering the research questions and fulfilling the research objectives. Please refer to **Chapter 4.1.7** for the according outcomes.

4.1.5 Pilot interview

4.1.5.1 Introduction

The pilot interviewee to validate the chosen approach and to test the research questions with was interviewee 0/1E, Director Spares Logistics and Pricing, who is responsible for both the spare parts logistics as well as spare parts pricing within Central/Eastern/Northern Europe for one of the main elevator companies in the world. The interview was conducted on 30.03.2015 in Germany and lasted about 90 minutes. In his role as Director Spares Logistics and Pricing, the interviewee has deep insights into the spare parts logistics processes within Europe, but also worldwide, as he is involved in global projects as well. Furthermore, he has been working in multiple companies in the elevator and escalator business area for more than 20 years.

According to the interview guideline, the interview was divided into four topics, i.e. general information, corrective maintenance process, influencing factors, and performance improvement. For a better overview, the insights given by the interviewee will be displayed in the same order. As explained in **Chapter 4.1.3**, the general information sub-chapter (**Chapter 4.1.5.2**) mainly deals with the context of the topic, spare parts logistics and corrective maintenance, as well as industry and company specifics. The corrective maintenance process sub-chapter (**Chapter 4.1.5.3**) gives insights into the different process steps as well as the role of response time and other competitive objectives in detail. **Chapter 4.1.5.4** and **Chapter 4.1.5.5** then finally describe in detail the perceived influence factors as well as improvement opportunities respectively.

The information described in the according sections and sub-chapters of this chapter highlights the main points identified during the interview. A full summary of the findings will additionally be provided in forms of tables to provide further details.

After the interview was conducted, the interview was transcribed and coded as explained previously. A summary of the key messages derived from this input is displayed at the end of every sub-chapter. For a better overview, the attached tables in the following chapters only show the main questions per focus topic. For a full list of the questions including the sub-questions, please refer to the interview guideline in **Appendix 1**.

4.1.5.2 General information

To give a general introduction to the business, the interviewee explained the background and the importance of quick services and the large number of service related employees in comparison to the total workforce (approximately 4.500 out of 11.000 employees for the interviewee’s company) within this area. A very large portfolio of elevators spread across the whole region has to be covered. Some areas, e.g. big cities, have a large number of elevator units on very small space, some other countryside areas have very few elevators spread over a fairly large space. In either situation, the interviewee stated that in case of sudden breakdowns, “nobody wants to be stuck in the elevator for long”, resulting in a need for extremely short service response times in emergencies. Simultaneously, the operators of the elevator units respectively the customers of the service are not interested in the logistics process itself. They only expect the elevator to operate and have a high availability. If the elevator breaks down, however, they expect it to be put back into work as soon as possible.

Furthermore, the interviewee explained the nature of the market, where the big players face fierce competition from smaller companies, especially in service, as servicing elevator units can be learned within a reasonably short time frame. Additionally, the fact that every company in the market can usually service all the other brands of elevators as well as their own units leads to a portfolio of different parts to be serviced ranging from 8,000 to 10,000, out of which 200 to 400 can be labelled as A-parts with high frequency usage. Weights and prices for parts obviously vary with such a large portfolio. However, most spare parts are fairly small and weigh less than 3 kg. The most expensive parts are controller boards, which can cost multiple thousands of Euros. Size wise the biggest parts that are still considered a spare part and not a modernization (e.g. new cabin, motor block, etc.) are door panels. In order to stand out of the competition, state-of-the-art service is necessary, according to the interviewee, as this is a key driver and a major contributor to revenues and margins for companies in the elevator business area. The expert furthermore claims to continuously "improve spare parts logistics, as it is considered a very important part of the business."

With regards to the types of maintenance available, the interviewee explained that a lot of different services are offered to the customer. Different service contracts state the different levels of service through the provider. For example, the interviewee explained that some customers only ask for so called oil and grease contracts, where the service technicians only do the basic maintenance on the respective units multiple times per year. With these contracts, break-downs are handled separately. Other contracts include general maintenance and repairs, however, spare parts have to be paid separately, and again others include full maintenance including all costs. These different types of contracts with all their sub variations generate different strategic ways of operation for the service providers naturally. While in full maintenance contracts preventive maintenance plays an especially important role in order not to be liable financially for the exchange of spare parts on that unit, with contracts that only include the maintenance but not the parts themselves, this is less of a factor. Here, customers of course also expect their units to have the maximum possible availability just like with full maintenance contracts, however, they know that when repairs are needed (regardless of discovery through preventive or corrective maintenance), these will cost extra.

In terms of service response time, this does not necessarily have a major effect, however, as all customers want their units in operation. Service response time agreements are therefore implemented within the respective contracts. If those response times are not complied with by the provider, this will cause penalties and eventually a dissatisfied customer who may change service providers.

Service level agreements vary from contract to contract. This means that one customer may ask for a service response time to a broken down unit immediately, e.g. in hospitals, senior citizens' homes or airports, while other customers, such as owners of office or apartment buildings may have higher tolerances as they usually have multiple elevators in those buildings and the effect of the broken down unit is not as dramatic. These agreements only apply to general break-downs. In cases where people are trapped in an elevator that broke down, reaction time needs to be within approximately 30 (sometimes up to 60) minutes regardless of the service contract in order to free the people. If this for some reason cannot be complied with, the fire-fighters are usually called for emergency rescue of the trapped people. The response time for the reactivation of the unit back to operation is then, according to the contractual agreements again.

In order to comply with the contractual agreements, to minimize the chance of trapped people in a unit and to fully satisfy the customer with high availability of their units, regardless of the contractual agreements it is therefore the goal of any service provider in this business area to prevent break-downs as much as possible. However, since this is not possible in 100% of the cases and even with the best preventive maintenance service available, break-downs occur regularly.

Constantly finding ways to optimize service response time therefore plays a vital role in the elevator business in order to stay competitive and in order to satisfy the customer, as stated by the interviewee. Furthermore, the interviewee stated that the service technicians play an especially crucial role in this business, as “they are the link between the customer and the company” and they have an extremely high impact on how quick services are provided to the customer, i.e. how quickly a unit can be back in operation after break-down.

A summary of the key findings in the general information topic from the pilot interviewee can be found in **Table 7**.

Topic	Main Questions	Inputs from Interviewees
0	Interview/Interviewee-Number	0/1E
0	Business Area	Elevator
0	Position	Director Spares Logistics & Pricing
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)
0	Years of Experience	>20 years
1	**How important is spare parts logistics in general for your company?**	• Fierce competition in the market • A few major players, but especially in service a large number of small/local providers • Every company in the market can service every unit from all companies • Necessary to have outstanding service in order to differentiate • Service and spare parts logistics is a major contributor to revenues and margins in the elevator business
1	**How important is corrective maintenance in spare parts logistics in your company?**	• Nobody wants to get stuck in an elevator: Quick corrective maintenance is extremely important • Elevator operators are not interested in the logistics, but simply want the elevator to operate all the time and without any issues • Even though preventive maintenance is a main focus area, break-downs occur on a very regular basis • Especially in emergencies, i.e. people stuck in an elevator, service response time is crucial • Corrective maintenance service is a major contributor to revenues and margins in the elevator business
1	**Please explain the context of your spare parts logistics corrective maintenance business.**	• 4.500 out of approx. 11.000 employees are service related • Large portfolio of elevators spread across the region • Portfolio in large cities and remote areas • Spare parts portfolio of approx. 8.000-10.000 different parts due to the nature of the market, where every company can service every unit • 200-400 A-parts • Weights and size vary, usually parts are fairly small and weigh less than 3 kg however • The most expensive parts are controller boards (multiple thousand Euros) • Door panels are the largest parts (which are not a modernization) • Different types of service level agreements exist • The service technicians play a very important role as they are the link between the company and the customer • Also, they have an extremely high impact on the service response time after a break-down

Table 7: Summary table of pilot interview key points for the general information topic

4.1.5.3 Corrective maintenance process

The corrective maintenance process in the elevator business area itself is described as follows by the interviewee: As soon as the issue of a broken down unit has been recognized by the customer/facility manager, he/she calls for help at the number provided by the service provider or through the phone installed in the elevator. This person is then connected to a central call centre, which collects all the necessary information and automatically sends a request for service to the mobile device of the service technician, who is responsible for that particular unit. If this technician is unavailable, according to the interviewee, "there is always a backup", and thus immediately another technician is contacted through his/her mobile device. The technician, depending on the urgency of the break-down (people in danger or not) goes to site immediately or plans a visit with regards to his daily maintenance route and with regards to the response time asked for by the customer in the service contract. Once the service technician is on-site, he/she identifies the issue on the unit. Sometimes the technician is able to do that alone, sometimes help from a supervisor, a colleague or the back office is required and asked for by phone. In the optimal case, the problem can then be solved right away with parts and tools available in the service technician's car stock. If that is not the case, the part to fix the problem has to be ordered. The correct part has to be identified in the spare parts catalog and needs to be ordered. In numerous cases, help to identify the exact spare part to be ordered is required as well. This is often done in the back office through highly experienced supervisors in combination with the purchasing department. If the part is on stock in a warehouse, it is delivered to the service technician. If it is not on stock, it has to be ordered first. Delivery of the part to the service technician can be conducted through numerous ways. Parts can be delivered to site, they can be picked up at the back office or a warehouse and they can also be sent to pick-up/drop-off points (PUDOs). A PUDO can be anything from a gas station that is open 24/7 to packing stations provided by logistics providers, garages and stores, etc. Additionally and where possible, parts can also be delivered overnight into the service technicians' trucks. As soon as the part are received by the service technician, he/she can repair the unit as quickly as possible, but also depending on the service contract requirements agreed upon with the customer. If the attempt to fix the unit fails, further investigations need to be made or different parts need to be ordered. This process structure, according to the expert, can be found in other business areas as well, especially with similar set-ups such as ATMs as well as weighing systems, etc.

Reasons for break-downs, according to the interviewee, are mainly due to wear and tear mechanical issues, e.g. doors, as well as electrical problems, e.g. on controller boards. In certain locations, e.g. train stations, etc. vandalism is a cause for break-downs as well.

General structures for the corrective maintenance process as well as the decision to install a service response time measurement are up to the local branches or regional centres. There is no general process available for this matter in the elevator business area of the interviewee's employee. Competitive factors in corrective maintenance, according to him, besides speed include quality, price, flexibility, dependability, prevention and safety.

Please refer to **Table 8** for an overview of the interviewee's key points for this chapter.

Topic	Main Questions	Inputs from Interviewees
0	Interview/Interviewee-Number	0/1E
0	Business Area	Elevator
0	Position	Director Spares Logistics & Pricing
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)
0	Years of Experience	>20 years
2	**How does the spare parts corrective maintenance process look like in your everyday work?**	• After break-down of unit, customer calls and is forwarded to call centre • Call centre sends notification to service technician, who is responsible for the unit • Service technician goes directly to the unit or plans a visit along his service route depending on urgency • At site, service technician identifies the issue • Optimally, elevator can be fixed right away with tools and spare parts available in car stock • If not, the missing parts have to be ordered • The parts, once available, will be given to the service technician (PUDOs, overnight deliveries, pick-ups from the warehouse, etc.) • The service fitter then solves the issue • The timeframe varies on the urgency of the issue
2	**Is the service response time in corrective maintenance measured already?**	• Service response time measurement is up to the local units, a general measurement is not available at the moment
2	**Are there clear structures/rules for the corrective maintenance process?**	• Structures and responsibilities are up to the local units, a general process is not applicable at the moment
2	**Why do break-downs occur?**	• Wear and tear are usually main causes for break-downs as well as electrical problems and vandalism
2	**What are competitive objectives in corrective maintenance?**	• Price, quality, speed, flexibility, safety, dependability, prevention

Table 8: Summary table of pilot interview key points for the corrective maintenance process topic

4.1.5.4 Influencing factors

With regards to the factors affecting the service technicians in the corrective maintenance process, the interviewee stated a large number of different influences.

When looking at the first process step of accessing the unit, the expert interviewee perceived this to be of very high importance with respect to the corrective maintenance process and the influence it has on the response time of the service technician. Three factors that have a particularly high influence for the interviewee are the accessibility of the unit, which includes the availability of keys and permissions to enter the property as well as the relevant mechanical facilities, the closeness of the service technician to the unit and the geographical location of the unit within a city or in a remote country side area.

With respect to the closeness of the technician to the unit, the interviewee explained that this is the reason for the large number of service related employees in the company as mentioned earlier. Since reaction times need to be short, usually a portfolio of units is serviced within close proximity, especially in cities. In more remote places, the driving times are longer, thus the portfolio of serviceable units per service technician is usually smaller in order to comply with the need for quick service response times. Even though this has a high impact on the process and obviously affects the service technician a lot with respect to the service response time in corrective maintenance, according to the interviewee, he states that "this can generally be controlled fairly well through the amount of service technicians available."

Keys for the building usually are stored at the facility management's office or within a key box readily available for the service technician to pick-up, not causing much of a delay. An issue that may arise in this context is the case, when the facility manager is not at his/her desk and needs to be found first. This can cause issues for the service technician, but only rarely occurs, as service technicians usually also always have telephone numbers to then contact the according people. The same accounts for permissions. These may cause issues in rare occasions of high security areas, like nuclear power plants or prisons, etc. In most of the cases, a set amount of service technicians are equipped with the necessary permissions and have previously undergone checks as soon as a service contract is signed in order to prevent issues from arising. Another problem that does have a larger effect on the service technician, however, especially in big cities, is the parking situation for the service cars. In these cities, sometimes the car has to be parked far away from the broken down unit, causing delays due to the need to find a parking lot, then to walk to the unit, and in case special equipment or a spare part is required, by walking back and forth between the unit and the parking lot. In more remote areas, this is usually not a concern.

In the process step of diagnosing the problem, which the expert also believed to be highly important in the process of corrective maintenance, "especially identifying the right part" and “having the right supporting material”, e.g. catalogs and mobile devices, were said to have a very high perceived impact on the service technician respectively the effect on the service response time. Experience and knowledge, regular training as well as the right tools were also stated to be important by the interviewee.

Especially the combination of identifying the part that needs to be changed or the issue that needs to be fixed as well as the supporting material that helps the service technicians in doing so seems to be a major problem that affects them at site and thus influences the service response time. Here the interviewee mentioned that usually not enough information is available on the parts for a quick identification. Particularly, since a lot of parts are not manufactured by the service provider, resulting in a very large number of different parts in the portfolio, it is extremely hard for the service technicians to know every part. According to the expert, article numbers, barcodes, etc. would be very useful, “but especially mechanical parts do not have that.” Electrical parts, especially the newer ones, usually have some information attached, which helps in re-ordering them quickly. This is not always the case, however, especially with old parts, where identification markings have worn off over time, etc. In those cases usually a lot of phone calls with colleagues, supervisors, purchasers or the back office are required in order to identify the part. Additionally, own research needs to be done in catalogs, online or electronically on mobile devices, which again consumes a lot of time, especially when these catalogs are not well organized or do not contain the needed information or parts.

Furthermore, in this context the interviewee then mentioned the importance of first time fixes and the right van stock available. This means, that once the part to be fixed has been identified, it of course would be ideal, “if the service technician has the right part in his [/her] car and can fix the elevator while he [/she] is there.” Otherwise, response time will be delayed once more through the ordering and delivering of the part and a second journey to site by the service technician. The same accounts for the right tooling. Obviously, the service technician in the ideal case should have the necessary tools and the right quality in tools in his/her toolbox in order to fix the unit right away instead of having to go to a depot or warehouse or to order them from the back office.

Due to these complexities and constantly differing circumstances, knowledge, experience and training are very valuable and are an important factor in order to keep response time as little as possible as well. Here, especially the exchange of information and knowledge among the service technicians are of major importance.

With regards to ordering parts, the interviewee felt that this has a very high importance for the effects on the service technician in corrective maintenance and service response time as well. He stated that “once the service technician is on-site and has identified the issue or the part needed, ordering is usually the next big issue." If ordering is required, the interviewee mentioned the necessity of good supporting material and tools as very important. Also he mentioned the complexity of the ordering process to have a very high influence on the service response time. The communication with the back office or warehouse was also stated to be influential.

According to the interviewee, the ordering process largely varies from country to country due to the different maturity levels. Whereas in Germany advanced laptops with installed service systems including customer and contract information as well as spare parts catalogs are available, in other countries, especially in eastern Europe, where the number of units under maintenance does not allow for investments in devices like that, ordering becomes a bit harder as multiple hard copy catalogs of different manufacturers have to be carried to site and ordering needs to be done through colleagues at the back office. This obviously takes more time than in advanced market settings. Again, here the interviewee mentioned the importance of having the right parts available in the car and avoiding this process altogether.

In terms of delivery of parts, this is also only necessary when the part is not on the service technicians van stock already. In these cases, however, according to the expert interviewee, the influence of the process step on the service technician and the service response time is perceived to be comparably high. The interviewee said that "the communication with the back office or warehouse is very important." In addition, he mentioned the delivery process and delivery mode to be very influential, e.g. the choice between PUDOs, overnight delivery, pick-ups from the warehouse, etc. Furthermore in this process, correct supporting materials and tools are of very high importance respectively, according to the interviewee.

Whereas overnight deliveries seem to be the most beneficial mode of transport, according to the interviewee, allowing for the parts to arrive in the car stock of the service technician overnight and thus being readily available to be used in the morning, this practice cannot be accomplished everywhere. He stated that "due to legal restrictions or company guidelines, it is not possible to have spare parts directly delivered into car stocks in all countries, regions and businesses." This is the case, as this mechanism requires the cars or vans to be parked in a certain area (usually one or two blocks) every night at a certain time slot, which in some regions is seen as an interruption into the private life of the service technician. PUDOs therefore are frequently used to overcome this issue. Another available mode of delivering parts, according to the interviewee are pick-ups from the warehouse by the service technician, which, however, are highly inefficient as the service technician has to drive additional amounts of kilometres and is unavailable for services during that time. Furthermore, deliveries right to site are also available.

In this context again, the location of operation is extremely important. In Europe and especially central Europe, parts can be moved quickly from a stock location to site, to a van stock or to a customer site. In other locations, e.g. Brazil, the distances and the circumstances are quite different, however, according to the interviewee. An example given by him states that “on average it takes 21 to 25 days to deliver a part from Sao Paulo in southern Brazil to Manaus in the Amazon rainforest. Here, overnight deliveries and PUDOs are basically impossible to be utilized in emergency settings or in break-downs with service level agreements more sophisticated than that.” In these cases of course, different concepts have to be applied and a local stock with emergency parts has to be maintained in order to support the service technician as much as possible so that high satisfaction of the customer, elimination of unit downtimes and quick service response times in corrective maintenance can be generated.

The last process step is the repair process of the unit itself once the right part is at site. The importance or the effect on the service response time and the service technician is perceived to be comparably medium levelled as stated by the interviewee. Experience and training both have been mentioned to have a high influence on the service technician, according to the interviewee, but in general once the technicians know what the problem is and they have the right part available, the repair usually does not cause much delay in the process. Especially with mechanical parts this is not an issue. Electrical parts, especially of third-party equipment providers, however, can sometimes cause issues as parameters, etc. have to be set correctly in order for them to function. Training and experience are thus important factors to consider. Additionally, a support centre particularly available for questions or even on-site support for third-party electrical equipment helps to shorten repair processes, according to the interviewee.

In addition to these direct operational influences, strategic factors on the process and the service technicians have a perceived high influence on the process and the service technician, according to the expert interviewee. Especially the large variety of spare parts which results from the variety of units under maintenance from different providers has a major influence on the service technician, according to the pilot interviewee. Other strategically derived influences, such as the units under maintenance per service technician, the amount of work on the units, customer contract specifications, out-of-office times and the availability of parts through contacts among colleagues also have an effect on the response time of the service technician in corrective maintenance, according to the interviewee. In general, it is always the goal to stick to the maintenance plan or service plan that is generated regularly for the service technicians. However, call outs or sudden break-downs usually change these plans immediately. According to the interviewee, especially flexibility is especially important in order to react to these issues optimally.

Furthermore, factors that cannot easily be influenced, such as traffic jams and weather conditions have to be treated with similar flexibility. According to the interviewee they generally have a very low influence on the service response time. Overall, this is mainly because these factors cannot or cannot easily be overcome and have to simply be accepted as possibilities to interfere with the plan or cause some issues.

Please see the following **Table 9** for an overview of the summarized results in this chapter.

Topic	Main Questions	Inputs from Interviewees
0	Interview/Interviewee-Number	0/1E
0	Business Area	Elevator
0	Position	Director Spares Logistics & Pricing
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)
0	Years of Experience	>20 years
3	**How is the service technicians' performance in corrective maintenance influenced?**	• See next points for details
3	**What are main factors in each process step that can be influenced operationally?**	• Large number of service technicians in order to secure proximity to units, even in rural areas • Keys to the units are available at facility management offices or key boxes usually • Delays are caused when facility management is not present • Permissions in high security areas, e.g. prisons or nuclear power plants may cause delays • Parking in large cities causes trouble very often • Identification of parts is crucial and a major contributor to delays • Catalogs need to be structured and include clear specifications and all parts necessary • Information on parts lacking • Mobile devices can support, if available • The combination of identification and having the right supporting material, i.e. catalogs, devices, car stock, tools, etc. is extremely important • Knowledge, training and know-how have an impact on service response time • First time fixes have a major impact on response time • Ordering has less influence on the response time • Once a technician is on-site and has identified the issue, most of the problems have been taken care of • Best case: spare part is in car stock, otherwise ordering through phone or mobile device, if available • The ordering process complexity has a high impact (direct ordering through laptops or mobile devices vs. identification in a catalog and then ordering through the back office (sophistication of this process varies from area to area)) • Good supporting material and tools are of importance in this case again • In-night deliveries, PUDOs not possible everywhere due to legal restrictions and company guidelines • Pick-ups from the warehouse cause additional driving time • Location is important: in Europe parts can be moved quickly, in Brazil it takes around 3-4 weeks to bring a part from Sao Paulo to the Amazon Rain Forest (Manaus) • To repair, experience and training are key to success • Especially electrical parts cause issues frequently • A support centre exists for third-party electronic equipment
3	**What are other indirect factors that can be influenced strategically?**	• Strategic factors have a medium influence on the process and the service technicians • Large variety of spare parts and units under maintenance have a major influence • Units under maintenance per service technician, customer contract specifications, out-of-office times and availability of parts through colleagues have a medium effect • Flexibility is very important to react to break-downs
3	**What are factors that cannot be influenced?**	• Traffic jams are not a major concern • Weather conditions are not a major concern

Table 9: Summary table of pilot interview key points for the influencing factors topic

4.1.5.5 Performance improvement

Overall it can be seen that a lot of factors influence the performance of the service technician and therefore have an impact on the service response time. It can also be seen, however, that the response time varies or can vary from case to case. Timing largely depends on the availability of the right parts as well as the performance of the service technician, which again is influenced by the operational factors stated in this section. Furthermore, there are also strategic factors and factors that cannot or cannot easily be influenced, e.g. the region of operation and the customer contracts with the service level agreements. In general, according to the interviewee, service response time can therefore vary from very few hours (two to three) in the best cases where access and identification are quick and easy, parts are available and repair can be done right away, to worst cases where identification, ordering or delivering of parts can take multiple weeks. In an average case, “a broken down unit, which is not an emergency with a need to rescue people stuck, is usually serviced and put back into operation within 24 hours to two or three days”, according to the interviewee. This shows that a lot of potential is still available in order to improve the corrective maintenance process. Here, especially important are the cases that exceed the service level agreements.

In order to reduce the service response times therefore and to assure complying with the contractual agreements, the interviewee was asked to share his opinion and knowledge on improvement opportunities in this process.

With regards to the accessibility and proximity of units, he therefore mentioned that one important focus area lies in optimizing routing and scheduling of service technicians. The service technicians should spend as little time as possible in the car and lots of time on-site. Here it is important to pay attention to having the same service technicians maintaining the same units whenever possible. As the service technician is the face to the customer and is therefore known, this simplifies access to the building and to site as well as general communication and communication in cases of the need to get approval to order a spare part of a certain value quickly. Furthermore, the service technician in these cases also knows the units, the normal issues arising and can usually react to problems quicker.

In terms of identification, numerous possible improvement opportunities are available, according to the expert interviewee. As mentioned before, a unique bar code or identification number on the most relevant parts could help to seriously improve this process step. Furthermore, online catalogs as well as electronically available catalogs on laptops or mobile devices with further identification levers such as dimensions, colours, descriptions, explosion drawings to look at the part from different angles, etc. would be very beneficial, according to the interviewee. In those catalogs, information on availability, re-order times, etc. could also be displayed. This could be addressed by implementing it in the construction process already. Once a new type of elevator is constructed, a list of all the spare parts with unique labelling as well as explosion graphics could be generated for own units. For third-party equipment, the information generation would be harder to retrieve, but could be done on a local level and then supplied into a data base possibly. Regions with less advanced circumstances should be supplied with catalog hardcopy updates regularly. However, “it needs to be the goal to have mobile and paperless solutions readily available for every service technician”, regardless of the area of operation, according to the expert.

On these mobile devices, possible improvements include direct ordering from the spare parts catalog, personalized information on the units under maintenance and a harmonization with the car stock. The device should be used to mark the number of parts used in a corrective maintenance process and replenish the car stock of the service technician automatically if needed based on the information entered into the system. The car stock itself should contain the most important parts in a quantity necessary to fulfill the service response times and simultaneously not create excessive stocks. Major improvements are possible in this area as another recent internal study at the company of the interviewee showed that about 80% of the recent car stock in Europe are non-moving parts that barely ever get used. The movement therefore and in the future could be monitored through the mobile device as well. As mentioned before, it is essential to optimize this also in order to eliminate the need to order and deliver parts and have multiple drives to and from the unit before it gets repaired in the majority of break-downs and corrective maintenance. A further improvement in this context could be to make all car stocks available to all service technicians. If one service technician in this case would not have a certain part, but another service technician had it available in the car stock, an exchange of parts could be organized. In these cases, scanning by barcodes would help to keep track of the stock movements. Scanning itself would be another improvement in general and whenever a part is moved from one stock to another or consumed in corrective maintenance.

The use of available resources to help the service technician is an additional improvement point. Besides the colleagues and the supervisors as well as the back office, specialized experts to be called just as in the example given previously about the electrical third-party equipment should be readily available and known to all service technicians also for other areas, e.g. mechanical issues, etc.

In terms of communication with the customer, the mobile device could store information on customer contracts. The service technician would then know up to which amount an order of a spare part can be generated without particular approval of the customer, which service level agreements are agreed, etc. This would accelerate the process of ordering parts.

When a part has to be ordered and is not available in the car stock, a supporting network with central stocks that have the major parts available is necessary. Waiting for an order lengthens the process drastically. Additionally, it is important to quickly receive the parts. A system of optimally delivering the parts to the service technician within the minimum time possible, regardless of that being overnight deliveries, pick-ups or PUDOs, etc. should be developed depending on the region of operation.

In order to repair, but also to identify, the right tooling is another essential part that needs to be focussed on. High quality tools readily available are essential for the service technician to efficiently fulfill the tasks. The same applies to trainings. Due to the large amounts and quickly changing structure of the spare parts portfolio and the units under maintenance, new techniques available to solve problems, etc. regular trainings can improve the response time in corrective maintenance.

Furthermore, a focus on preventive maintenance, especially on older units, is essential to reduce the efforts in corrective maintenance. Condition monitoring devices or black boxes recording data and informing the back office respectively the service technician directly about necessary exchanges of parts will reduce response times drastically.

Another important factor mentioned by the expert interviewee is “to never lose track of local necessities.” While a lot of improvements can be generated centrally and work for most of the areas, it is important to allow a certain flexibility in order for service technicians to be optimally supported in the corrective maintenance process regardless of the location and region of operation.

Overall, “within the entire process, it is essential to have a major focus on customer satisfaction”, as little downtime as possible and quick response times, especially in cases of locked people in the elevator, according to the interviewee. With these focus points in mind, improvements remain a continuous need for any service company, not only in the elevator business area.

An overview of the results is summarized and displayed in **Table 10**.

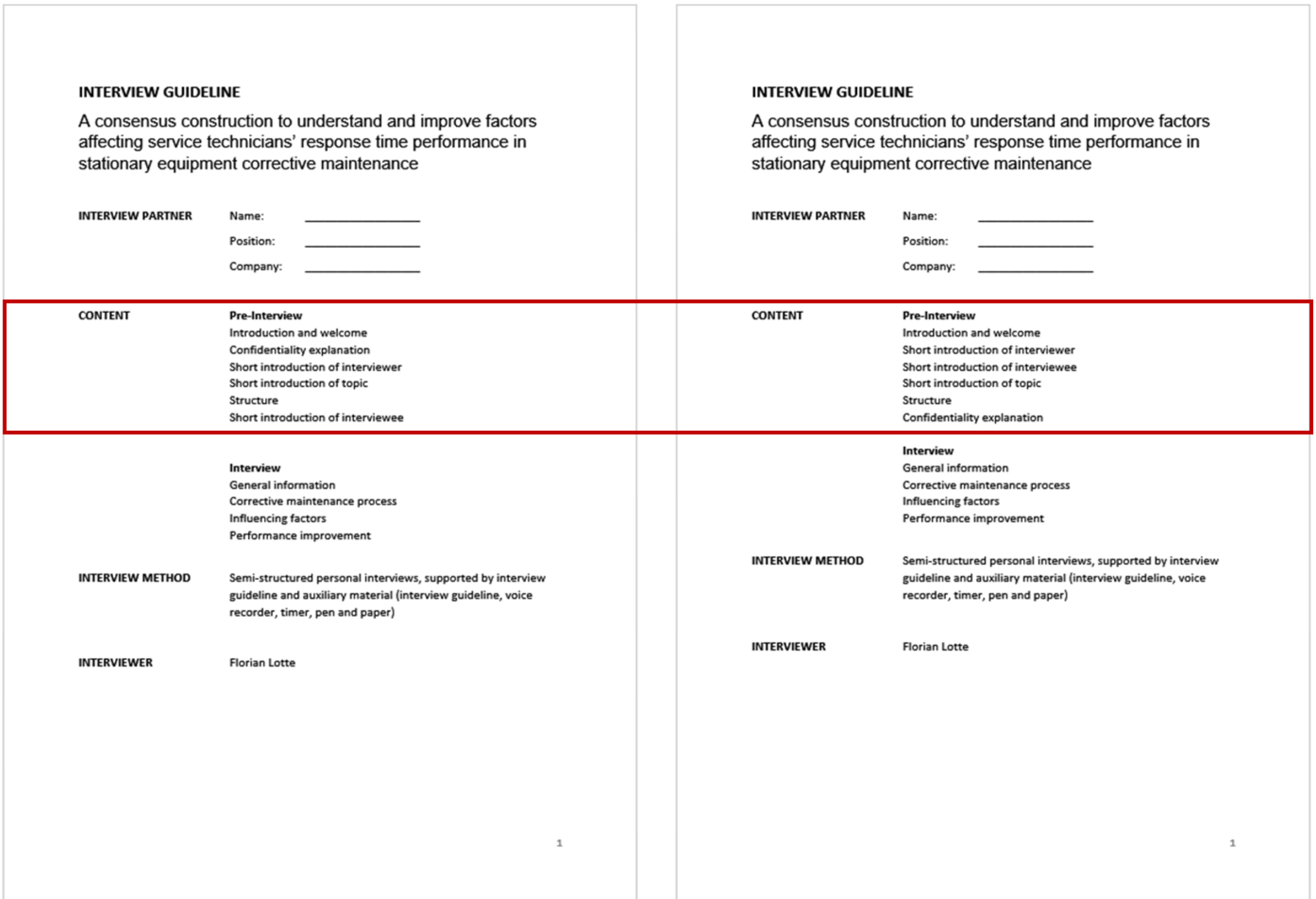
Topic	Main Questions	Inputs from Interviewees
0	Interview/Interviewee-Number	0/1E
0	Business Area	Elevator
0	Position	Director Spares Logistics & Pricing
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)
0	Years of Experience	>20 years
4	**How might the negative impacts on the service technicians' performance in corrective maintenance be overcome?**	• Route optimization and scheduling have to be focussed on • Communication with the customer • Know the customer, know the units through having the same service technicians take care of a set portfolio of units • Unique bar codes and identification numbers on the most relevant parts • Online catalogs • Mobile devices • Further identification levers such as dimensions, colours, descriptions, etc. • Explosion drawings • Electronically available information on re-order times, availability, etc. • Improve the data flow of key information to fill the data base (from construction on) • Direct ordering through online/electronic catalogs • Personalized information on spare parts portfolio on service technician's laptop/mobile device • Harmonized car stocks with personal adjustments depending on units under maintenance • Automatic replenishment of car stock • Make all car stocks available to all technicians • Scanning by barcode to keep track of stock movement • Implementing specialized experts task force teams • Mobile devices can also store customer information • Supporting network of central stocks that has major parts available all the time is the necessary backbone • Define multiple options to deliver to customer/service technician in order to be flexible and react to circumstances • Right tooling with high quality equipment needs to be available • Regular trainings • General focus on preventive maintenance is highly important • Never lose track of local circumstances and necessities • Customer focus • Improvements in this area are a continuous need

Table 10: Summary table of pilot interview key points for the performance improvement topic

4.1.6 Methodological impact of pilot interview

Based on the approach suggested by Bryman et al (2011), after the pilot was conducted, the interviewee and the interviewer analyzed the interview together in order to identify further issues, to talk about structural factors, and challenge the questions asked. The author then finalized the interview guideline based on the changes suggested and discussed.

One of the major changes with regards to the structure of the questionnaire was the order of topics in the pre-interview. The final version, which is described in **Chapter 4.1.3**, was organized slightly differently prior to the pilot. Whilst the final version of the guideline was subdivided into the introduction and welcome, followed by a short introduction of the interviewer and the interviewee, a short introduction to the topic as well as an explanation of the structure of the interview, before it was concluded with the explanations regarding confidentiality, the structure differed during the pilot. After the introduction and welcome, first the confidentiality part was explained, before the interviewer introduced him-/herself. This was followed by the introduction of the topic and the structure before finally the interviewee introduced him-/herself (**Figure 34**).



INTERVIEW GUIDELINE

A consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance

INTERVIEW PARTNER	Name: ______________ Position: ______________ Company: ______________
CONTENT	**Pre-Interview** Introduction and welcome Confidentiality explanation Short introduction of interviewer Short introduction of topic Structure Short introduction of interviewee
	Interview General information Corrective maintenance process Influencing factors Performance improvement
INTERVIEW METHOD	Semi-structured personal interviews, supported by interview guideline and auxiliary material (interview guideline, voice recorder, timer, pen and paper)
INTERVIEWER	Florian Lotte

1

Interview guideline prior to pilot interview

INTERVIEW GUIDELINE

A consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance

INTERVIEW PARTNER	Name: ______________ Position: ______________ Company: ______________
CONTENT	**Pre-Interview** Introduction and welcome Short introduction of interviewer Short introduction of interviewee Short introduction of topic Structure Confidentiality explanation
	Interview General information Corrective maintenance process Influencing factors Performance improvement
INTERVIEW METHOD	Semi-structured personal interviews, supported by interview guideline and auxiliary material (interview guideline, voice recorder, timer, pen and paper)
INTERVIEWER	Florian Lotte

1

Interview guideline after pilot interview

Figure 34: Differences in pre-interview structure prior and after pilot interview

Particularly the position of the introduction of the interviewee at the end of this section seemed not well chosen. The pilot interviewee remarked that giving the interviewee the opportunity to introduce him-/herself earlier generates two major advantages: First of all, he/she feels more valued, being able to introduce him-/herself at the beginning of the interview rather than at the end, which is very important and needs be considered with respect to the ethical guidelines. Second of all, the interviewee is involved in the interview right from the start and does not need to listen to all the other information prior to his/her own involvement in the topic.

Furthermore it was observed through the pilot interview that it made more sense to finish off the pre-interview section with the confidentiality topics. A number of reasons were discussed with regards to this change after the pilot. First of all, the topics with regards to confidentiality have been mentioned and introduced in detail to the interviewee already during the initial contact stage by the interviewer. A repetition seemed to be more appropriate at the end of the pre-interview, because at this stage, the context of the research has been explored and explained in more detail and beyond what has been discussed during the initial approach. By placing this topic at the end of the pre-interview and thus right before the actual interview, additionally, the importance of confidentiality was aimed to be reemphasized for the main part of the conversation/interview.

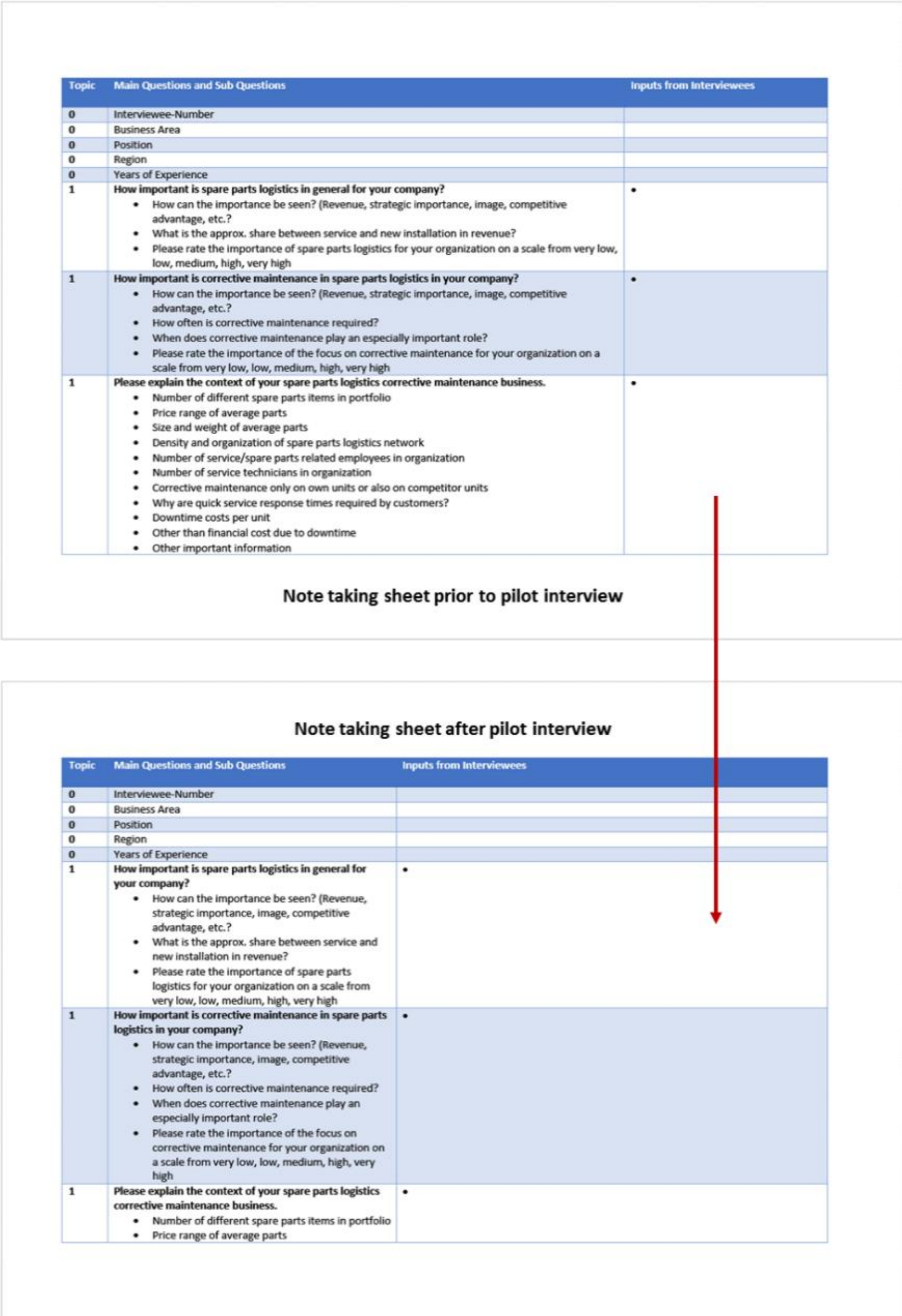
It was also discovered through the pilot interview, that a number of additional information were needed in the guideline. Especially in the pre-interview section, where the foundation of the interview was laid, a deeper explanation of the context was necessary. Through the pilot interview it was discovered that a more detailed description of corrective maintenance was needed, the process that was focused on, i.e. from a call for service through the customer until final repair of the unit, needed to be clearly defined and stated and the definition and role of a service technician needed to be clarified. For the rest of the interviews, this information was therefore included. Cohen et al's (1997) model (see **Figure 18**) was also added to the appendix of the interview guideline for further clarification.

With regards to the questions asked in the main interview, it was the main intention of the author to use the pilot to double check, whether or not the questions had a clear contribution to the research questions and to deliver results to fulfill the research objectives together with the interviewee. Each question was therefore looked at with the pilot expert after the interview had been conducted. All questions were confirmed to be valuable. Also it was reconfirmed through this interview that a strict order of going through the questions was not possible. Therefore, when answers and statements with regards to a specific question were made that led to answers and statements also with respect to other sections of the guideline, it was agreed that ticking off the relevant points/questions in the questionnaire was an appropriate method of making sure that every aspect necessary had been taken care of during the interview.

Furthermore, it was observed that a few further questions were needed that had been missing in the pilot interview. For instance, a question towards response time measurement was therefore included in the interview guideline afterwards. Some questions needed to be reworded slightly in order to create better direct understanding without much explanation and additional examples, especially for factors affecting service technicians, a clear question with respect to competitive objectives, etc. were decided to be included in the interview guideline in order to generate thick and rich results valuable for fulfilling the research aims. The final interview guideline, as stated previously, is displayed in **Appendix 1**.

Another major change resulting from the pilot interview was the decision to prepare a questionnaire in German. Prior to the pilot, only an English version existed. However, with regards to the ethical guidelines as well as the knowledge of the pilot interviewee of experts relevant to this research both in observations as well as interviews not speaking English needed to be considered.

In the context of creating overview tables for the interviews and observations, during the pilot interview the necessity for more space for note taking was observed. The amount of data produced was larger than expected. The previously created template to capture notes during the interviews was therefore changed in order to allow more space for note taking (see **Figure 35**). Additionally, blank back-up pages were increased. The final version of the note taking sheet, as described in **Chapter 4.1.3**, is displayed in **Appendix 3**.



Topic	Main Questions and Sub Questions	Inputs from Interviewees
0	Interviewee-Number	
0	Business Area	
0	Position	
0	Region	
0	Years of Experience	
1	**How important is spare parts logistics in general for your company?** • How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • What is the approx. share between service and new installation in revenue? • Please rate the importance of spare parts logistics for your organization on a scale from very low, low, medium, high, very high	•
1	**How important is corrective maintenance in spare parts logistics in your company?** • How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • How often is corrective maintenance required? • When does corrective maintenance play an especially important role? • Please rate the importance of the focus on corrective maintenance for your organization on a scale from very low, low, medium, high, very high	•
1	**Please explain the context of your spare parts logistics corrective maintenance business.** • Number of different spare parts items in portfolio • Price range of average parts • Size and weight of average parts • Density and organization of spare parts logistics network • Number of service/spare parts related employees in organization • Number of service technicians in organization • Corrective maintenance only on own units or also on competitor units • Why are quick service response times required by customers? • Downtime costs per unit • Other than financial cost due to downtime • Other important information	•

Topic	Main Questions and Sub Questions	Inputs from Interviewees
0	Interviewee-Number	
0	Business Area	
0	Position	
0	Region	
0	Years of Experience	
1	**How important is spare parts logistics in general for your company?** • How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • What is the approx. share between service and new installation in revenue? • Please rate the importance of spare parts logistics for your organization on a scale from very low, low, medium, high, very high	•
1	**How important is corrective maintenance in spare parts logistics in your company?** • How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • How often is corrective maintenance required? • When does corrective maintenance play an especially important role? • Please rate the importance of the focus on corrective maintenance for your organization on a scale from very low, low, medium, high, very high	•
1	**Please explain the context of your spare parts logistics corrective maintenance business.** • Number of different spare parts items in portfolio • Price range of average parts	•

Figure 35: Differences in note taking sheet prior and after pilot interview

Based on the changes made after the pilot, the reworked and final interview guideline was also discussed with the supervisors of the university as well as the three business experts involved in the doctoral research process in order to make sure that everything necessary was covered to generate appropriate research results. Due to this reconfirmation, further minor additional changes were included in the guideline, e.g. the importance of out-of-office times and the impact they may have on the response time in corrective maintenance.

Given the methodological changes made to the interview guideline after the pilot had been conducted, the high value of including this step in the empirical research process has been shown to the author. Also, this pilot helped the author to become more comfortable with this method and work on his interviewing skills, as suggested by Gläser et al (2010).

Furthermore, based on the information and data generated through the pilot, in a final step of this empirical research phase, it is the intention to verify the appropriateness of the chosen approach in order to answer the research questions and fulfil the research objectives. This will be displayed in the next chapter.

4.1.7 Appropriateness of approach

Taking the qualitative information and data generated through the pilot, the chosen approach of using in-depth semi-structured interviews in combination with process observations and analysing available data and document sources has proven as an appropriate combination of methods in order to generate new knowledge with regards to the research questions and research objectives. Especially by combining and triangulating these three information sources, the insights into the corrective maintenance processes in the different business areas are diverse, provide numerous different perspectives and help to successfully answer the research questions and to fulfill the research objectives based on thick and robust data. This will explained in more depths in the following paragraphs.

The first research question thereby aims at adding clarification and knowledge around the competitive objectives in stationary equipment corrective maintenance, to address in more detail the competitive objectives besides timeliness/speed and their effect on it, to identify similarities and differences across different business areas and to identify, if additional competitive objectives may be applicable in this context and thus need to be added to the frameworks available in literature.

1. What are the competitive objectives for stationary equipment corrective maintenance processes within the different business areas, i.e. elevator, mining equipment and IT hardware, they serve, and how do they impact service response time?

The pilot interview has clearly addressed this issue. Whilst all five factors identified in literature (see **Figure 10**) have also been mentioned and seen as relevant by the interviewee, two additional competitive objective, i.e. safety as well as prevention, have been addressed by the expert in detail.

Specifically highlighted by the expert thereby was the safety aspect. A main priority in the elevator industry is given to break-downs with people stuck in units. As people may be directly influenced by a break-down and be stuck in a unit, quick response times are essential in order to free people within extremely short periods of time.

Another highlighted competitive objective, as stated by the interviewee, is quality. Customers want high quality units that are in operation. Usually, elevators are needed to lift heavy loads of equipment (in production and logistics settings, etc.) or to transfer people (in offices, hospitals and apartment buildings, etc.). Elevators out of order disrupt these processes and thus need to be dealt with quickly. Break-downs, however, cannot be eliminated in 100% of the cases. The goal of the service providers respectively the service technicians therefore is to fix any issues as quickly as possible with the highest quality possible to comply with the initial customer requirement of using the elevator as a vehicle for their own processes. This competitive factor, according to the interviewee, coexists with prevention. Of course, in order to keep the unit in operation, preventing break-downs and thus eliminating response time for corrective maintenance is the ultimate goal of any operator. However, this cannot be accomplished in all cases and break-downs still occur, as stated by the interviewee.

Flexibility, dependability, price and their effects on corrective maintenance in the elevator industry as well as their impact on speed, i.e. response time, have been addressed by the interviewee in a similar way.

It can therefore be seen, that by interviewing multiple experts with high experience and knowledge in three different business areas, a thorough understanding of the competitive factors in this context as well as their effects on service response time can be expected. Adding to the interviews by conducting numerous process observations as well as using available data and documents will provide further insights into the competitive factors to consider in stationary equipment corrective maintenance as well as their effects on response time in the three business areas observed.

The second research question then focusses more in detail and depth on the service response time. The objective thereby is to specifically identify factors that are perceived to have an impact on the service technicians' service response time in the different business areas and thus influence the objective of timeliness/speed negatively.

2. In the corrective maintenance processes in the three business areas described, what factors are perceived as affecting the service technicians' response time performance?

Similarly to the first research question respectively research objective, this research question and objective are addressed thoroughly by the chosen approach.

The pilot interview clearly shows a multitude of factors that affect the service technician in the corrective maintenance process. As only one pilot interview was conducted at this stage, the remaining interviews are expected to add large amounts of data, information, diversity and viewpoints with regards to influence factors in stationary equipment corrective maintenance response time in the community studied. Process observations, which build on the interview guideline as well as data/document analyses will supplement the identification of factors as well as similarities and differences between the cases. Robustness of the data generated through the triangulation of these methods is expected in order to provide results that contribute to answering the research question and fulfill the research objective in this matter.

With the perceived factors influencing the service response time in stationary equipment corrective maintenance in the different business areas identified in the previous question, the objective of the third question aims at identifying potential process alteration opportunities that are perceived to improve the service technicians' needs, i.e. to minimize response times in corrective maintenance and thus improve the objective of timeliness/speed.

3. What is the perception towards how the process can be altered to better serve the service technicians' needs, i.e. to minimize response times in corrective maintenance?

As already seen in the previous question, the pilot interview already shows the multitude of possible alterations and improvements available to the corrective maintenance process, which might help to improve this process. Further interviews, process observations and data analysis will strengthen these outcomes, generate further ones and create a solid baseline to build upon.

Accordingly, with the generated input in terms of competitive objectives, perceived influence factors on service technicians in stationary equipment corrective maintenance response time processes as well as perceived improvement opportunities, it is the objective of the fourth and final research question to provide a consensus construction that demonstrates what needs to be taken into account to introduce these findings in business practice in the community studied. Furthermore, it is the intention with this construct to build a baseline for further research.

4. How can a consensus construction be developed in order to identify what needs to be taken into account to introduce these alterations in business practice?

By utilizing and triangulating the large variety of sources and viewpoints of inputs generated for the three business areas observed, a consensus construction for the community to be used in business practice is expected. As stated previously, the amount and diversity of inputs thereby aims at reaching a saturated information level in the topics discussed to generate thorough and valid results.

The results are thereby geared to provide recommendations for the community, but also look into incorporating the differences of individual business areas as well as companies within a certain business area.

In addition to the practical applicability of the findings, the pilot shows that knowledge is created that may lead to further research in this area. By identifying relevant competitive objectives, perceived influence factors on service technicians in stationary equipment corrective maintenance response time, perceived improvement opportunities to support service technicians, as well as by developing a consensus construction around it, further research needs are expected. These can build upon the findings provided by this thesis.

Overall, by applying abductive, qualitative, multiple case study research with the selected methods of semi-structured interviews, process observations as well as data/document analyses, contributions both to knowledge as well as business practice are expected as shown by conducting the pilot for the empirical research phase. The chosen approach has thereby proven to be applicable and appropriate in order to answer the research questions and fulfill the research objectives identified.

4.2 Phase 2: Case studies and result documentation

4.2.1 Introduction

As displayed in **Figure 28** and introduced in **Chapter 3.4.2.3**, this chapter deals with the results of the three case studies conducted and their documentation. It thereby describes the results from the data/document analyses, the process observations conducted as well as the in-depth semi-structured interviews. As for the pilot, also here, the key findings are explained in detail in the course of this chapter. Furthermore, summaries of all results are displayed to show a full picture per sub-chapter. Additionally, in this chapter, coding/clustering is performed in preparation for the analysis of the results (displayed in **Chapter 4.3**). As with every phase in the authors research, the results of this phase have been cross-checked and validated by the business experts involved in this research as well as the two university supervisors.

This chapter is clustered into four sub-chapters in addition to this introduction. The second sub-chapter describes and reemphasizes the methodological approach, before the results of the elevator business area are displayed in the third sub-chapter. This is followed by the results of the mining equipment business area as well as the IT hardware business area. All three cases thereby are furthermore subdivided into five sub-chapters, i.e. introduction, general information, corrective maintenance process, influencing factors, and performance improvement.

4.2.2 Methodological approach

After concluding the pilot phase of this research, which was used to validate the methodology and appropriateness of the approach to contribute to closing the research gap, the main part of the empirical data generation was initiated and undergone in this phase. The major goal of this stage was to generate and document data and information from multiple sources to be used in order to answer the research questions, fulfill the research objectives as well as to contribute to both knowledge and business practice with this study.

As outlined both in the research design (**Chapter 3.4**) as well as the preparatory stage of the empirical research (**Chapter 4.1**), for the three cases conducted, a choice of three methods has been selected to generate data and results. These sources namely were documents and data, process observations as well as in-depth interviews. In accordance with Yin (2014), the multitude of sources was selected to create thick and robust data through triangulation to be utilized to build a consensus construction in the community studied.

The collection of existing and already available data and documents from the three business areas was started in April 2015. Thereby, and with the permission of the respective mentor from each business area, relevant documents, data and data bases were screened by the author in terms of the objectives and research questions of this thesis. Relevant inputs were extracted and documented for the purpose of analyses. Additionally, the respective markets were continuously screened for developments and trends throughout this research. Further data, which was received through the experts during or after the interviews as well as process observations was also included in the data base and utilized for this research. In some cases, interviewees and experts provided data to strengthen their arguments by themselves, in other cases, for instance when specific examples were given by an expert, the author asked for documents or other materials to support the experts' statements. This was always done in accordance to the ethical guidelines. If data was not available or could not be handed to the author for confidentiality as well as any other reason, this was accepted without questioning. The purpose of using data and document analyses was to generate an overview for the author, to increase his knowledge base and understanding and to utilize the information as a baseline for the interviews and process observations.

In terms of process observations, for the elevator business area, the results from a previously conducted study by the author were utilized. During this study, five process observations in five different countries, i.e. the Netherlands, Belgium, France, Switzerland and Austria, were conducted with a similar focus topic. Just like for this thesis, this study thereby specifically focused on after-sales services, corrective maintenance, competitive objectives in corrective maintenance, influence factors and optimization potential. Thereby, in-depth process observations were conducted within corrective maintenance processes. The documentation from this study was included in this research therefore with the permission of the respective business area mentor.

For the other two business areas, one process observation each was conducted in this phase. The choice of venues, based on opportunistic and snowball sampling (Patton, 2002) thereby was derived through contacts generated prior to the empirical research phase. It was assured by the author in close cooperation with the business mentors that the selected observations were conducted on highly experienced and knowledgeable experts. A normal business day was selected to conduct the observation together with the respective expert. Just like explained in the preparatory stages of this research, the ethical guidelines were strictly followed in this concept. The experts were approached well in advance, informed about the research purpose and questions were answered, if necessary. They were given the interview guideline to familiarize themselves with the topic and they were furthermore informed about the utilization of their statements, neutrality and anonymity, the possibility to review all notes and the option to withdraw from participation at any stage without reasoning.

The observations were not conducted as interviews. The guideline prepared was mainly used for the author to check, if all relevant topics had been covered. The process observation method was utilized to understand the process, the circumstances, ask arising questions, include unexpected events and find content to the research based on a viewpoint different than interviews and documents.

The largest amount of input for this research, however, was generated through the semi-structured in-depth interviews. The first regular interview (excluding the pilot) thereby took place on 05.05.2015. The last interview was conducted on 22.12.2015. Overall (including the pilot), a total of 18 in-depth interviews with 20 experts (two joint interviews conducted with two experts each) both from the strategic as well as the operational side from all three business areas (i.e. elevator, mining equipment, and IT hardware) and from various locations and regions worldwide were conducted in this phase. Overall, seven interviewees from the elevator business area, nine from the mining equipment business area as well as four from the IT hardware business area were interviewed. The majority of interviews was conducted in person. A few, due to the geographical distance between the author and the experts, were conducted by telephone. It was agreed in all interviews that notes were to be taken and that these were double checked and potentially added onto after the interviews, as suggested by Flick (2009). Also, as stated previously, it was intended to record and transcribe all interviews, as suggested by Flick (2009), Gläser et al (2010) and Bryman et al (2011). However, not all experts gave their permission to be recorded. In these cases, this was accepted without questioning in accordance with the ethical guidelines. More time to protocol all statements was agreed to be utilized, however, in order to capture everything stated by the experts.

The choice and selection of interview experts, as explained in **Chapter 3.4.2.3**, and as in the choice for process observations, thereby followed the concepts of opportunistic and snowball sampling (Patton, 2002) as well as saturation (Mason, 2010; Baker et al, 2012; Fusch et al, 2015).

Utilized to conduct the interviews was the final version of the interview guideline, which was developed after the pilot. As stated before, interviewees thereby had the chance to be interviewed in German or English and as for the pilot as well as the process observations, the ethical guidelines were strictly complied with by the author in all cases. In cases, were interviews were conducted in German, the approach suggested by Regmi et al (2010), in which forward translation was followed by backwards translation to assure the right meaning was transferred, was applied in order to minimize biases. In these cases, more time to conduct the interviews was needed. The interviewees were informed in the preparatory stages accordingly.

In order to be able to summarize the results from the interviews, reduce and display the data in an appropriate manner and to prepare for the analysis, i.e. to generate meaning and/or conclusions in terms of the research questions and research objectives (**Chapter 4.3**), as suggested by Miles et al (2014), transcription has been applied, as suggested by Flick (2009), Gläser et al (2010) as well as Bryman et al (2011), for instance. An extract of a transcription protocol is displayed in **Table 11**.

Person speaking	Content	
…	…	
Interviewer	If we look at the accessibility of a unit, can you say something about the factors affecting service technicians and possible improvements there?	E, RQ2/3, RO2/3
Interviewee	Oh yes, yes. There is always a process that you have to go through when you arrive on a site. Basically the machine rooms are locked. You have to find the person responsible to hand you the keys - the keys for the machine room and the release keys for the elevator doors.	IF10, ODI, DAU
Interviewer	Uhuh.	
Interviewee	Now depending on the type of building that could be quick or it could be a long time. And I'll give you two extreme examples. If you go to, let's say, a home for the elderly, you will go to the main office and the warden will be sitting there and they will just hand you the keys and away you go. You are in and you can work on the lift within two to three minutes. I have also been to high security hospitals where all your equipment is searched and documented. I am now talking, for instance, about hospitals for criminals.	IF11, ODI, DAU
Interviewer	Ah ok.	
Interviewee	It could easily take you two hours to get into these places. Also, if you are working in a nuclear power plant that job is going to take you the entire day.	
Interviewer	Wow. Really?	
Interviewee	Yes, because you have to go through security and you are going to have to take your passport, you are going to be thoroughly checked and there is a procedure to get dressed and they give you clothes to wear and when you come away from the job you have to be screened again for radio activity. So there are two extremes – one, you could be in and out a job within five minutes, and in the other it is a full day's job, with anything in between.	IF11, ODI, DAU, CO
Interviewer	And what would you say is the regular case - the easy access or the harder ones?	
Interviewee	Yeah, I would say the easy ones. There are a lot of jobs where the access time is about ten minutes.	
Interviewer	Ok.	
Interviewee	Again, it can also depend on the geographical site. If it is a large hospital and if you have to go and see the hospital engineer to get the keys and then you have to walk half a kilometre to the lift, you know, that is a factor. But I'd say, in general, you'd gain access to the lift within ten minutes.	IF10, ODI, DAU
Interviewer	Ok. And does it make a difference if you are in downtown London or somewhere in the backcountry?	
Interviewee	Yeah, yeah yeah. Well it depends. If you are asking about, if you are including traveling time to the site, then it is going to be a lot longer than ten minutes, of course.	IF5, ODI, DAU
Interviewer	Yes.	
Interviewee	You might have a 30 minute drive, you might have a 30 minute journey on the London underground system. So yes, there are a lot of factors in this.	
Interviewer	And do you know any actual measures that are being taken to optimize this? What is being done in this sector?	
Interviewee	Yeah, the guys in the United Kingdom they have a routing system where they use PDAs and the offices will know the location of all of their operatives. So when they get a call, they can send the nearest one. And then he can either accept or reject and then they look to the next nearest. So the local branches can control this process and remain flexible.	IP10/29, TA, BO CO
…	…	

Table 11: Extract example of interview transcript from interviewee 6E

Interviews that were not recorded, were protocolled in a detailed format similar to this in order to capture all content given by the interviewees.

Based on the transcribed and protocolled interviews, additionally in this phase, coding and clustering of the results was applied, as suggested by Flick (2009), Miles et al (2014) and Yin (2014), for example. This is also displayed in the extract provided in Table 11. Thereby, a multitude of different codes and clusters was used. On a high level, information was clustered and coded to show the applicability of data to different research objectives (RO) and research questions (RQ), e.g. RQ1, RO3, etc. Input thereby could be marked as relevant for multiple ROs and RQs. Also, on a high level, it was shown to which business area a data point or information belongs, i.e. elevator (E), mining equipment (M), and IT hardware (I).

Furthermore, it was the intention of the author to identify and highlight competitive objectives (CO), perceived influence factors (IF) as well as perceived improvement potentials (IP) in the data generated. Also, it was the intention to highlight, which IPs may influence which IFs. Therefore, each IP and IF were given a number (1, 2, 3, 4, etc.) in order to provide a possibility to show the connections. IPs thereby could also be displayed to influence more than one IF.

Additionally, it was the intention of the author to show, which IFs are an operative/direct influence (ODI), which IFs are a strategic influence (STI), and which IFs are a non-influenceable circumstance/other factor (NIC). In ODI, an even more detailed clustering was generated. Here, the different process steps in corrective maintenance, i.e. remote diagnosis (RED), driving to/accessing the unit (DAU), on-site diagnosis (OSD), ordering (ORD), receiving (REC), and repairing (REP) were subdivided. For IPs, a further subdivision was implemented to show, whether an improvement can be related to technical assistance (TA), back office support (BO), or technician enabling (TE). An overview of these main clusters/codes used for this research is displayed in **Table 12**.

Cluster/code	Explanation
RQ	Research question
RO	Research objective
E	Elevator business area
M	Mining business area
I	IT hardware business area
CO	Competitive objective
IF	(Perceived) influence factor
IP	(Perceived) improvement potential
ODI	Operative/direct influence
STI	Strategic influence
NIC	Non-influenceable circumstance/other factor
RED	Remote diagnosis
DAU	Driving to/accessing the unit
OSD	On-site diagnosis
ORD	Ordering
REC	Receiving
REP	Repairing
TA	Technical assistance
BO	Back office support
TE	Technician enabling

Table 12: Clusters/codes

Combinations of codes/clusters were used to highlight their relevance in multiple aspects. Based on the transcribed and coded protocols and interviews, summary tables were generated to display the information in a structured and reduced manner.

Coding and clustering were furthermore also applied to the information generated in the process observations as well as the data and document analyses. It was added to the information of the interviews to provide a full and triangulated overview over the generated data and its relevance to the different aspects needed in order to answer the research questions and fulfill the research objectives. All data has been stored in the data base created for the purpose of this research on the PC of the author.

To further strengthen this thesis and remain up to date in the research context, in addition to the empirical research, newly arising literature with relevance to the topic was continuously screened throughout the entire empirical research phase and added to this research, wherever appropriate.

Based on the approach described for this phase, the following sub-chapters display the reduced information generated from the three cases and the methods applied, i.e. semi-structured interviews, process observations and data/document analyses. Each business area case and the research conducted will be introduced, before the research results are displayed in the same structure as the results of the pilot interview, i.e. general information, corrective maintenance process, influencing factors, and performance improvement. The outcomes of this phase have been cross-checked and validated both by the business area mentors as well as the university supervisors.

4.2.3 Elevator business area

4.2.3.1 Introduction

In the elevator business area, a total of seven interviews including the pilot interview were conducted between 30.03.2015 and 11.08.2015. Out of the seven interviewees, four had a strategic and three had an operational background. In order to get a broad image, the strategic experts were chosen to receive a global image of the topic with the strategical implications to the business. These highly experienced experts had at least ten years of experience, the majority of them even more than 20 years, and were all familiar with the business not only in a certain geographical area of the world, but at least an entire or multiple region(s). Some experts even had responsibilities up to a global level. For the operational experts, again only highly experienced experts with focused knowledge from at least more than 20, some even more than 30 years of experience in a very specific region or country were chosen to be interviewed. This aimed at including the hands-on experience of operational activities in specific markets. All three experts came from three different regions, namely Germany, the United Kingdom and Switzerland/Liechtenstein, in order to include a variety of different examples. All experts, both from the strategic and the operational side of the business, were in leading functions in the organization.

Furthermore, the interviews were conducted in one-to-one personal settings whenever possible, i.e. six out of seven cases. One interview was conducted through telephone conference. All seven interviews were recorded and for all interviews handwritten notes were taken. The average net duration of the interviews was approximately 85 minutes, i.e. without the time needed for backwards translation, reviews, etc. An overview of the expert interviewees, who were interviewed from the elevator business area can be found in **Table 13**. The key points mentioned by the interviewees were summarized and are displayed in **Appendix 4.**

Inter-view	Inter-viewee	Inter-viewee per BA	Date	Business Area (BA)	Position	Strategic/ Operational	Region	Base	Years of Experience	Interview Mode	Notes	Recording	Comment
0	1	1E	30.03.15	Elevator	Director Spares Logistics & Pricing	Strategic	Central/Eastern/ Northern Europe & Worldwide (for certain projects)	Germany	>20	Personal	x	x	Pilot
1	2	2E	05.05.15	Elevator	Service Supervisor	Operational	Germany	Germany	>30	Personal	x	x	
2	3	3E	08.05.15	Elevator	Senior Vice President Global Logistics	Strategic	Worldwide	Germany	>20	Personal	x	x	
3	4	4E	19.06.15	Elevator	Head of Service	Strategic	Central/Eastern/ Northern Europe	Germany	>20	Personal	x	x	
4	5	5E	22.06.15	Elevator	Vice President Strategy, Markets & Development (SMD) & Product Lifecycle Management (PLM)	Strategic	Central/Eastern/ Northern Europe	Germany	>10	Personal	x	x	
5	6	6E	02.07.15	Elevator	Technical Manager	Operational	United Kingdom	United Kingdom	>30	Telephone Conference	x	x	
13	16	7E	11.08.15	Elevator	Head of After-Sales Service	Operational	Switzerland/ Liechtenstein	Switzer-land	>20	Personal	x	x	

Table 13: Overview of expert interviewees from the elevator business area

In addition to the interviews, findings from process observations in five locations from a previously conducted study were included. These observations, as previously mentioned, were conducted in the Netherlands, Belgium, France, Austria and Switzerland. In each location, the author accompanied an experienced service technician on their respective daily jobs for a full working day as well as looked at other related processes with logistics experts in this context in these locations.

Furthermore, available data regarding the spare parts processes was analyzed and used for this case study. This data was mostly obtained through data bases and document bases, and where applicable, from the interviewees and company experts during the observations.

Just like in the pilot interview, the overall results are documented in the four topic sections of the interview guideline, i.e. general information, corrective maintenance process, influencing factors as well as performance improvement in the next chapters.

The general information topic thereby focusses on creating a general understanding on the business context and the significance and importance of service, spare parts logistics and corrective maintenance in the business context. The corrective maintenance process topic aims at fully understand the process with regards to the elevator business area as well as the competitive objectives, before in the third sub-chapter, i.e. influencing factors, the perceived key factors that influence the service technician with respect to the service response time in corrective maintenance are identified. Finally, the last topic section, i.e. performance improvement, shows what can be done to improve the situation for the service technicians and thus influence response time in the corrective maintenance process.

4.2.3.2 General information

The servitization maturity level, as observed in this business area, is perceived to be on a comparably average/medium level. Overall, both spare parts logistics and service in general as well as the sub category of corrective maintenance are, however, perceived to be very important within the elevator industry by all interviewees. According to the interviewees, numerous factors explain this significance. One main factor for this business area is that the elevator market is extremely competitive with a few major players and a large base of smaller providers, both in new installations as well as service. In order to stick out of the mass, service and thus spare parts logistics are important tools to differentiate. When looking at the potential, according to interviewee 2/3E, Senior Vice President Global Logistics, approximately 50% of the revenues in this market are generated through services. Out of those service revenues, roughly 30 to 35% are generated through repairs. If repairs included in full maintenance contracts are added, up to approximately 50% of the service revenues come from corrective maintenance.

Furthermore, a broken down unit in this business area usually means production loss, e.g. as stated in the example given by interviewee 1/2E, who is Service Supervisor with >30 years of experience in Germany and who has stated that, for instance, “in the Veltins beer brewery, the elevator is essential for the production to run as planned, as goods need to be carried onto different floors in their production facility.” In other cases, broken down units generate or hinder processes as well, e.g. in hospitals, senior citizens’ homes, office buildings, etc. On another level, also the comfort of residents in apartment buildings, etc. can be influenced by elevators not in operation. It is therefore crucial for any provider offering services in this business area, according to the interviewees, to secure quick response times and units in operation. This is even truer once people get stuck on a broken down unit. In these emergency cases, corrective service on the unit needs to happen immediately in order to rescue the people. In order to avoid production loss, process interruptions as well as emergencies, most interviewees therefore also mention that the core focus in after-sales service in this business area is preventive maintenance. However, as break-downs cannot be eliminated fully (i.e. “on average 1.5 to 2 call outs per unit per year in Europe”, according to interviewee 4/5E, Vice President Strategy, Markets & Development (SMD) & Product Lifecycle Management (PLM) in Central/Eastern/Northern Europe), corrective maintenance is a major focus area to secure quick fixes of units and thus fulfill customer requirements. As these corrective maintenance operations are the face of the company to the customer, according to interviewee 5/6E, Technical Manager in the United Kingdom with business experience of >30 years, also the image of the company depends on these operations.

Service levels are therefore generally agreed within the contracts. Normally the customer can choose from three different options: oil and grease, which only includes oiling and greasing plus minor adjustments and visual observations on the lift (here the customer pays for everything that exceeds this service), basic service and break-downs (once hours of service that were contracted are exceeded, the customer will pay for the additional service) and full maintenance (everything is included). Whilst in oil and grease as well as basic service and break-downs, the strategy needs to focus on generating margins through the service itself, in full maintenance contracts, it must obviously be the goal of the service provider to focus on preventive maintenance as much as possible in order to avoid repairs and thus to keep costs low. As mentioned before, “emergencies are always prioritized. In all other cases, the technician will service and repair a unit based on the service level agreements as well as the planned routes and schedules”, as stated by interviewee 13/7E, Head of After-Sales Service in Switzerland/Liechtenstein. It is the ambition and goal, however, to service all units under maintenance in cases of call outs within 24 hours.

Overall, the experts interviewed operate in a company employing roughly 24,000 service employees worldwide. Due to the possibility of servicing all elevator related equipment both from own as well as third-party productions, the portfolio of different parts counts approximately 100,000 different items, with approximately 200 to 400 A-parts. Most of these parts are comparably small and weigh less than 3 kg, e.g. screws, light bulbs, push buttons, batteries, etc. However, weights and sizes vary, with certain parts weighing up to 25 kg such as frequency inverters and door panels. Door panels are also the largest parts in size, which are not a modernization, e.g. a new motor or a new cabin, etc., according to interviewee 0/1E, Director Spares Logistics & Pricing in Central/Eastern/Northern Europe. The most expensive spare parts in general are electronic controller boards, which cost up to multiple thousands of Euros.

Equally diverse as the spare parts portfolio in this business area are the locations of units. While a lot of units are found in high density areas such as big cities, a lot of units are also spread out in less numbers in more remote and rural areas. For units in specific geographical regions, e.g. the Swiss Alps or the Brazilian rainforest as well as in large cities like Sao Paulo, different approaches and concepts are required in order to assure quick services.

Including the main warehouses, branch stocks, car stocks, technician's stocks, customer stocks, e.g. at airports, etc. about 35,000 different stock locations exist worldwide to service the units under maintenance in the portfolio. Countries and regions are thereby organized in branch structures to provide close proximity and quick response times to the customers as well as the possibility to react to specific geographical circumstances. According to interviewee 2/3E, this branch structure is also a result of efficiency targets. He states that "whilst an average service bill in the elevator industry roughly costs 200 to 800 Euros, the drive to the unit for a service technician usually costs around 100 Euros", making it a major cost contributor. A second drive to the unit is therefore highly inefficient with high margins being targeted and thus needs to be avoided wherever and whenever possible, especially through car stocks. Car stocks therefore usually consist of around 35 to 50 of the most important standard parts, according to interviewee 1/2E.

As the organization is much decentralized, different article codes and descriptions for the same parts exist. Furthermore, pricing structures are not globally fitted and oftentimes, supplies of old spare parts for old units under maintenance run out without notice. These issues, as well as trends such as subcontracting service on the one hand whilst trying to create a unique selling point through service and aiming to create a full customer experience with the offering on the other hand, according to interviewee 3/4E, Head of Service in Central/Eastern/Northern Europe, need to be carefully balanced and handled strategically and globally in order to be successful in the market. In this aim, especially the service technician plays a crucial role, according to interviewee 0/1E, as he or she is the link between the company and the customer and has a major impact on the service response time after a break-down.

4.2.3.3 Corrective maintenance process

In general, it can be seen from the process observations and interviews that the corrective maintenance process in the elevator business area runs by the same principles in various locations globally, with minor adaptations and/or differences depending on the region.

According to the interviewees as well as from what was seen throughout the process observations and documents, a call centre structure exists normally. In most countries, especially in the main markets such as Germany, France, etc. a central call centre will be the first point of contact for customers. In smaller markets, e.g. the Netherlands or the United Kingdom, the customer, in case of a broken down unit will call the nearest branch office of the service provider. From these call centres or branches, the technicians are assigned for the respective jobs. Usually, as stated in numerous interviews, the assigned technicians are the technicians who normally service the units. The main advantage here is that the technician knows the customer and knows the unit. The chances of a smooth and quick fixture are therefore higher. In case of a technician not available due to holidays, work on another unit or alike, the nearest colleague will be informed about the unit and the need for corrective maintenance. Emergency cases are always handled with the highest priority. Other jobs will need to be left in these cases. The drive to the unit can take anywhere from a few minutes up to multiple hours depending on the region, road and traffic circumstances, etc. Also, in cases where service is required outside of the office hours, the drive to the unit usually will be extended because fewer emergency service technicians, who then cover a larger area, will be assigned to the respective units.

Depending on the urgency as well as the service level agreement with the customer, the technician then drives to the unit immediately or schedules it into his/her routes within the next days. After the service technician has gained access to site, he or she will then identify the issue. As seen from the process observations, in some cases the customer will even hint the technician in the right direction. In other cases, the technician will have to figure out the problem alone. In some countries, e.g. Germany, the technician will be supported through diagnosis tools and electronic mobile devices to accelerate the identification. In smaller countries or markets, these tools are not always available. Identification of issues or parts might therefore take longer. A rough estimation from the colleagues during the process observations in the Netherlands, Belgium, France, Austria and Switzerland was that it takes about 5 to 15 minutes in the best cases and up to several days in the worst cases. The worst cases are when the right parts cannot be identified. Then, according to interviewee 2/3E, “an escalation process will be started and experts will come in.” First, these might be supervisors. Secondly, if that does not help, experts and specialists will have to come in and sometimes even fly in, especially on third-party equipment. The average time for an issue diagnosis is 1.5 to 3 hours, according to interviewee 1/2E.

Once the issue has been identified, the problem needs to be solved. According to interviewee 2/3E, “approximately 70% of all call outs can be solved without spare parts ordering”, due to the available tools and spare parts in the car stock. In the other 30% of the cases, the service technician needs to order a part. Depending on the value of the repair service, an approval process needs to be initiated first. In Switzerland for instance, according to interviewee 13/7E, anything up to 500 CHF (Swiss Francs) can be solved without explicit approval of the customer, as it was agreed upfront in the service level agreement. These values may vary from region to region. Other regions do not have a process like this and will need to initiate an approval process at all times, resulting in longer service response times.

As soon as the approval has been cleared, the ordering procedure again depends on the region of operation. Usually, a colleague from the warehouse or a branch office is contacted in order to get the right part for the technician. If the required part is on stock in the warehouse, branch, or another car stock, this ordering process is quickly handled by the responsible people. If the part is not on stock, however, ordering may delay the process again, as it has to be sourced from a vendor first. Reception of the part is then delayed as well. Especially with third-party equipment, but also own products coming from the manufacturing centres, delays in delivery are common. In Switzerland and other countries alike, customs at the border oftentimes delay the process as well, according to interviewee 13/7E.

In general, the service technician has different options to receive a part as quickly as possible. In some countries, e.g. the Netherlands and Switzerland, parts can be delivered to the technician’s car overnight. In other countries, e.g. Germany, this is not possible due to legal restrictions. Another option for deliveries are PUDOs on the routes of the service technicians. PUDOs can be gas stations, 24/7 shops, post boxes, a home address, garages, etc. Furthermore, the technician can also order the parts directly to site or to a branch office, where they will need to come in and pick it up. Especially when parts are on stock, a delivery within a few hours or overnight is possible. During the process observation in the Netherlands, an emergency delivery example was shown to the author, where pensioners were hired to deliver spare parts to site right away. A process exists, where the pensioners are called in emergency situations, pick up the parts from the warehouse and drive right to the technician. For the company, this is cheaper than an express delivery by courier and very convenient for the service technician as he/she does not have to come in to pick up the part. Instead, it is made available to them within a few hours on-site. In cases where ordering and delivery delay the process drastically, work around solutions, e.g. using parts from other functioning, less priority units, to temporarily overcome an issue, are followed in some countries. This is not done everywhere, however, according to the interviewees.

As soon as the parts are available to the technician, he or she can then fix the unit. If the unit still does not operate after the attempt, the process has to be repeated. Obviously, a first time fix must be the goal of any service company and second trials have to be avoided in order to secure quick response times, low costs and a high quality image, as stated by interviewee 0/1E.

Overall, according to interviewee 2/3E, “in 80 to 90% of the cases, a broken down unit can be fixed within a day” on a global average. Special occasions and the factors explained within this context increase the service response times in the other 10 to 20%. Especially in emergency cases, however, the lived expectation (as there are not laws or rules) is that within 20 to 30 (sometimes up to 60) minutes, the corrective maintenance has been initiated to rescue locked up people. In other cases, longer response times depend on the service level agreements.

On a global level, there is no measurement KPI for the service response time in corrective maintenance as well as there are no set rules or structures globally, according to the interviewees. The general process, as described above, is handled individually on regional levels as well. Therefore, structures and KPIs are implemented to a larger extend in some countries than in others. From the process observations and the interviews that cover multiple regions worldwide, only in Switzerland and Austria, a clear response time KPI was mentioned to be used to measure the performance per customer with live monitoring and data exchange into an analysis tool.

According to the interviewees, the reasons for the need of corrective maintenance pointed all in the same direction: the most used parts, i.e. the doors, are the main reason for failure in general as they wear and tear. In addition, electrical issues and vandalism cause for failure very often. Material issues are usually not an issue.

Furthermore, during the need for corrective maintenance, eight different competitive factors were mentioned by the interviewees, observed during the process observations as well as seen in documents. Five of these reconfirm Slack et al’s (2014) competitive objectives displayed in **Figure 10** respectively **Figure 15**. These are namely speed/timeliness, flexibility, dependability, price, and quality. In addition to these five competitive objectives, safety, security as well as prevention were identified to be of major importance for the community studied in the elevator business area. This is displayed in **Figure 36**. The results will be utilized further in the consensus construction, which is described in **Chapter 4.3**, in order to answer the research questions and fulfill the research objectives.

Figure 36: Competitive objectives identified in the elevator business area (Own extended figure based on Slack et al, 2014)

4.2.3.4 Influencing factors

With regards to the factors affecting the service technician in the corrective maintenance process, a large number of points were stated by the expert interviewees. Influencing factors could also be observed in the process observations as well as documents and data. Due to the large amount of data generated, a selection of factors will be explained in detail in this chapter. A full overview of all factors identified in this context is given in **Table 14**.

First and foremost it could be observed that operational factors including driving and access to the unit, diagnosis of the issue remotely and on-site, ordering of parts, reception of parts, and repairing the unit were perceived to be very important by the interviewees. Strategic factors were also perceived to be important, but seen as less influential than operational factors. This has been observed for non-influenceable circumstances/other factors as well, which were perceived as rather low influence sources.

In terms of driving to and accessing the unit, a multitude of factors were mentioned by the experts as possible response time increasers. Driving to a unit location can have a significant impact on the response time for instance. Especially in large cities with lots of traffic or very little parking options, this can cause delays. Also, and as mentioned before, geographical circumstances, such as for units in mountain regions, according to interviewee 13/7E, or islands according to interviewee 4/5E, have an influence on the response time and need to be planned accordingly. As stated by numerous interviewees also, the amount of service technicians within a specific region has an influence on the response time. The larger the base of service technicians is in a particular area, the smaller the portfolio of units to be serviced by each service technician needs to be and thus the less driving can be arranged as units will be in closer proximity. In certain situations and with large numbers of units under maintenance, e.g. at major airports, etc. service technicians are permanently located on-site to reduce service response time to a minimum, according to the interviewees.

Access to the unit itself, however, is usually not an issue, according to multiple experts, as key boxes and/or responsible people from the facility management are usually on-site, thus normally causing little interruption with regards to response time. This only becomes an issue in high security areas such as prisons, nuclear power plants, airports, etc. where security control takes a very long time and thus increases the response time drastically from time to time.

With regards to the identification of an issue, further factors influencing the service response time were given by the interviewees. According to interviewee 2/3E, “a major factor for delays occurs during the customer call at the call centre already.” At the moment, service requests in this business area are only dispatched to the technicians in these call centres as well as branch back offices instead of asking intelligent questions and offering remote help. According to this expert, 20 to 30% of the call outs could be handled remotely and fixed immediately, allowing for extremely efficient service. On-site, depending on the country or region of operation, some technicians have diagnostic tools to identify an issue electronically-based. In some other regions, these devices are not available. Furthermore, according to interviewee 2/3E, intelligence in the entire diagnostic system is missing with clear diagnosis structures, etc. Also, what oftentimes causes issues in this context, according to this expert, is that “too quick diagnosis due to missing structures generates problems.”

Identifying the right parts is yet another major issue in order to comply with quick response times, according to the experts. Here, especially the availability of high quality catalogs with clear structures, specifications and all necessary parts and updates available is of high significance in order to have quick response times. Reality shows, however, that the catalogs usually are not up to date, are missing pictures and explanations, drawings or 3D-models in order to identify parts quickly, according to the experts. Also, electronic devices with state-of-the-art catalogs are missing. Instead, hard copy catalogs are used in most markets and regions, generating long identification and thus response times. In addition to the catalogs, information on the parts is highly important to identify them quickly. This information, e.g. the article number or the producer, is oftentimes missing, however, according to interviewee 0/1E. Furthermore, the difficulty increases as different article numbers for the same parts are used in different regions. The support of tools and devices such as globally applicable catalogs, diagnostic tools or identifiers on the parts are therefore extremely important, especially due to the fact that the amount of parts increases quickly with the increasing amount of different suppliers of parts as well as elevator units. “Knowing all of those different parts of the top of the head, even for the very experienced and knowledgeable technicians, is impossible", according to interviewee 3/4E.

The availability of mobile devices as well, is a crucial factor for quick response times. Laptops and/or smartphones are, however, not globally available for all service technicians as observed during the interviews and process observations.

If an issue cannot be identified with the available knowledge, experience, tools and catalogs, colleagues will need to be contacted, pictures will be sent and help, online support and research will be offered through supervisors, purchasers, etc., which again, however, increases the overall service response time.

Once the issue and the spare parts have been identified, an approval process for the exchange of parts needs to be complied with. This, depending on the regulations and people who need to be involved, can have a negative impact on the response time, according to the interviewees.

Once this is sorted, however, the parts are either in the service technician's car stock or need to be ordered. In order for quick response times, obviously the best solution is to have the necessary parts immediately available in the car stock. The unit can then be fixed right away and response times are quick. If the part is not in the car stock, the parts will have to be ordered from a warehouse or back office in the branch. "The ordering process for this is complex usually", according to interviewee 0/1E, however, and thus has a high impact on the service response time. Especially in less sophisticated areas, this may still be a paper based process or multiple phone calls are required in order to receive a specific part. Once that has been done, the branch or back office then checks, whether or not the part is available on stock or needs to be ordered from a supplier, which can include the own manufacturing centres.

If a part is not available and needs to be sourced, ordering can extend response times quickly. Especially in regions, where parts will have to be sent over a large distance, have to pass customs or very specific or old parts are needed, response times are drastically increased. According to interviewee 3/4E, "especially old parts, for which alternatives are missing, usually cause major delays." Also, third-party parts are sometimes hard to source and therefore increase reaction times. Local purchasing options, especially for commodities, according to interviewee 1/2E, are also not considered and used often enough. From the interviews and process observations it could also be seen that ordering the right parts can be critical in order to avoid long response times.

When a part is available, different options exist for the technician to receive it. Picking up the part at a branch office most likely will take the longest time, as additional driving will be required, according to the interviewees and as experienced in the process observations. Other options include PUDOs along the routes or sending the parts to site through express services. Also overnight deliveries into service technician's cars are an option in some countries, not everywhere, however.

Once the service technician has the parts needed available, he or she can then repair the unit. Here, especially the right tools, but also experience and know-how are the major factors that can decrease response times in corrective maintenance, according to the interviewees. The goal for the repair job always has to be to have first time fixes, meaning that the issues are resolved in the initial case. Everything in addition to this initial case will drastically increase the response time on the service. In addition, communication and exchange of information is of key importance for the service technicians, however, the base for this is not given everywhere and thus only happens irregularly and in an unstructured manner, according to interviewee 1/2E. To have high quality tools available is also extremely important. These tools, however, should not be too heavy so that they can be carried right away. Heavy tools are usually left in the car by the technician until it has been identified what needs to be done. The tools then need to be fetched from the car, again adding to the response time.

Overall, it is stated unanimously by all experts that training is a very important factor for technicians to stay on top of the processes, have high customer orientation and know-how to react in each situation. To build their own knowledge and self-improve, according to interviewee 13/7E, "a lot of technicians take notes regarding their units under maintenance." This should be supported in a structured way so that knowledge is captured and experiences can be exchanged.

Further operational factors on the service technicians that influence the service response time are flexibility, IT support, the service cars with big trunks and navigation systems, which are not available everywhere, planning of service routes centrally with the decentral and flexible adaptation possibility, and last but not least a focus on the well-being of the service technicians and a focus on their needs, especially with the high fluctuation of technicians and the difficulty of finding high quality service technicians in the market, according to the experts.

As mentioned before, according to the experts, strategic factors are perceived to have less influence on the service response time than the operation factors just mentioned. However, according to the experts, they have a high influence nonetheless.

The fluctuation of service technicians combined with the difficulty of finding well trained and experienced people is an issue that influences the response time. Also out-of-office times, where only emergency personnel are on duty, obviously has an effect on response times for call outs. The focus of the top management for this topic is missing, according to some experts, as well as keeping up to pace with the digitalization of the world. The amount of work per service technician, i.e. the units under maintenance in one's portfolio, also has an impact on the service response time on an individual level. Another interesting point that influences the service response time is mentioned by interviewee 3/4E, who states that "the intrinsic motivation of each and every service technician needs to be strategically addressed." Furthermore, "the differentiation here needs to be made between technicians who see themselves as problem solvers and technicians who see themselves as proactive eliminators and prohibitions of failures."

Also mentioned already were the factors, which have an influence, but cannot be influenced, such as traffic jams, weather conditions, the infrastructure as well as legal regulations, laws and customs. These factors have to be accepted as a given with regards to service response times in corrective maintenance, according to the experts.

An overview of all the perceived factors identified to be relevant in stationary equipment corrective maintenance response time through the interviews and process observations conducted as well as the documents and data analyzed are displayed in **Table 14**. This table thereby shows all identified influence factors mapped onto the different process steps as well as with respect to direct/operational factors, indirect/strategic factors as well as other factors/non-influenceable circumstances respectively. These results will be utilized and prioritized as part of the consensus construction development described in **Chapter 4.3**.

Influence type	Process steps	Influence factors
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information
		Offering remote help/service
		Experience/knowledge/know-how
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)
		Technicians located on-site (direct access/little travelling)
		Prioritization of jobs/dispatching/planning
		Routing/scheduling
		Availability of key boxes on-site
		Availability of facility management/(security) personnel on-site
		Access to units in high security areas (safety/health tests, etc.)
		Cars not equipped with navigation systems/GPS
	Diagnosis (on-site)	Availability of diagnostic tools
		Availability of diagnostic intelligence structures
		Too quick diagnosis and thus not identifying the entire issue
		Availability of high quality spare parts catalogs/manuals
		Availability of electronic devices/support
		Information/barcodes/RFID/scanning functions on spare parts
		Information on customer/unit/other information
		Expert structures to identify issues/spare parts
		Experience/knowledge/know-how
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)
		Availability of car stock/site stock
		Availability of stock location network with quick deliveries
		Complexity of ordering process (electronical/paperless vs. manual)
		Ordering the right part(s)
		Availability of old parts and missing alternatives
		Availability of third-party parts
		Utilization of local purchasing options
	Receiving	Availability of different delivery options to be flexible
		Pick up of spare parts at warehouse
		Delivery to pickpoints/PUDOs
		Delivery to service technicians' vans/cars/trucks
		Delivery to site
		Availability of express/emergency deliveries
	Repairing	Experience/knowledge/know-how
		Availability of the right (quality) tools
		First time fixes as main goal/repair plan
		Terms/conditions/liabilities/service level agreements/contractual agreements
		Communication and exchange of information possibilities
Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician
		Number of service technicians to secure proximity to units
		Training possibilities
		Fluctuation of service technicians/scarcity of qualified technicians
		Out-of-office times
		Top management attention for corrective maintenance/service oriented mindset within the company
		Keeping up to pace with market trends
		(Intrinsic) motivation of service technicians
Other influences	Non-influenceable circumstances	Traffic jams
		Weather conditions
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)
		Laws/regulations/customs

Table 14: Perceived influence factors identified in the elevator business area

4.2.3.5 Performance improvement

In order to improve the response time in corrective maintenance based on the perceived factors affecting the service technicians in this process, a large number of possibilities was mentioned by the interviewees, observed in the process observations and documents analyzed. Again, a selection of the information identified will be explained, before an overview is given in **Table 15**.

Starting with a customer call at the call centre, one major improvement area, according to interviewee 2/3E, is the introduction of smart questions and manuals with instructions on how to deal with certain situations. This, according to the expert, would drastically increase the possibility of remotely solving issues at the unit without sending a service technician to site and thus reducing the response times. Also the information generated through smart questioning could be used to pre-inform the technician about the issue and thus improve the chances for a first time fix. Additionally, for special issues, experts could be sent right away without the prior visit of a service technician.

With regards to driving to the unit/accessing the unit, one improvement opportunity mentioned by numerous experts is the routing optimization as well as improved scheduling of the service technicians. In this context, one improvement aspect mentioned by interviewee 4/5E is so called geo-tracking, which allows dispatchers in the back office or call centre to look at each service technicians location through global positioning system (GPS) localization. He mentioned that "whilst it seems obvious to be the best option to send the service technician, who knows the unit and the customer, and who usually services the unit, especially in rural areas with long travel times, sometimes it may be better to send a closer technician from an adjacent area in order to reduce response times." Please see **Figure 37** for an illustration of the concept. It has to be stated that the use of GPS data to localize service technicians may be forbidden in certain countries. Additionally, continuous updates are necessary in order to maintain an optimum in scheduling and routing.

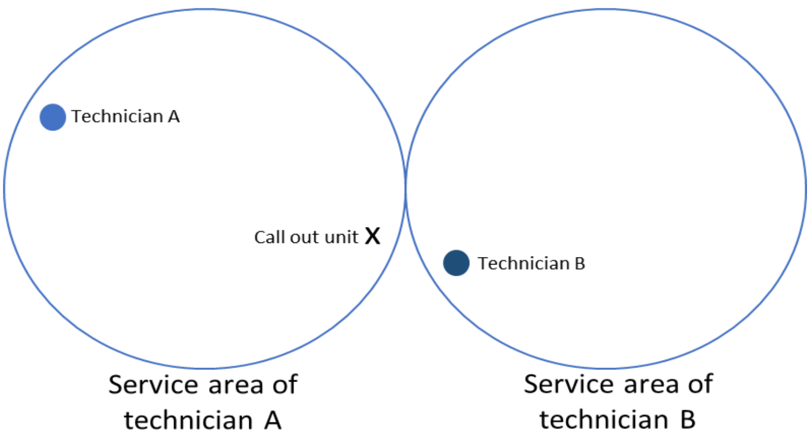


Figure 37: Geo-tracking concept (Own figure based on concept explained by interviewee 4/5E)

Furthermore, according to numerous interviewees as well as observed during the process observations, navigation systems should be implemented as a standard in every service technician's car.

In order to comply with the parking issues in big cities, new concepts should be incorporated into the general processes, according to the interviewees. Some concepts are even practiced locally already, however, the knowledge about them is not shared within the company worldwide. While special parking permits can usually be obtained everywhere or even a note in the windshield may be effective, especially in emergency situations, other concepts besides the technician driving a service car should be applied, where needed. In some places, technicians are driven by a driver, who will then circle the streets picking up and dropping of other technicians until the service has been finished on a particular unit. Other concepts to be applied include the use of motorcycles, the utilization of public transportation, etc. Especially in these cases, another concept, i.e. the service bus, with a larger portfolio of parts comes in handy. The portfolio of parts and tools in this bus is bigger than in normal car stocks. As motorcycle or public transport users only operate on minimal equipment, these buses should be readily available to serve the technicians in a particular area to quickly finish the job. Resident technicians, especially at airports, etc. are also an option, as observed during the interviews and in the documents analyzed.

Once on-site, the technicians can be better supported with regards to response time with a variety of improvement options, according to the interviewees. Especially during identification, the spare parts catalog available to the technicians needs to be drastically improved. The catalogs should be available online and on mobile devices. This implies that every service technician has a mobile device, which is also seen as a necessary improvement unanimously by the interviewees. All catalogs available should be integrated. This means to include all own products and all third-party equipment as well as commodities. All parts need to be easily identifiable through a unique article number, descriptions, dimensions, etc. Pictures from various angles for every part would highly benefit the identification process of the technician as well. Here, "a fixed process installed to photograph every new part as soon as it is added to the portfolio should be implemented", according to interviewee 13/7E. Additionally, 3D-drawings and/or explosion drawings of crucial parts should be available through the catalog. In order to make it even easier for the technicians, the portfolio displayed could be categorized for the unit under maintenance that the technician is working on including the bill of material

(BOM) installed. Regular catalog updates are especially essential in order to benefit the service technicians, as stated by numerous interviewees.

Besides the catalog improvements on the mobile devices, further improvements on these devices themselves can improve the process. The implementation of a web shop for direct ordering and purchasing of parts would reduce the response time. A side benefit would be additional sales through other customers. Electronically available information on re-order times, availability of parts, stock locations of the nearest needed parts, information on the customer or the units under maintenance, contractual information as well as captured information, e.g. on work around solutions in a database or wiki, etc. should be added to give the service technician all the information required to do his/her job efficiently and effectively. Mobile devices should also be used to make the process of information exchange, e.g. through internet access and the possibility to send pictures, easier for the technicians. Overall, according to the experts, the mobile device should create a paperless working environment.

In terms of identification, the use of new technologies could also drastically reduce response times, according to the interviewees. Besides the available diagnostic tools for electronical parts for own equipment, the identification of third-party electronic equipment should receive an increased focus. Furthermore, especially the use of image recognition software for mobile devices, according to interviewee 13/7E, or concepts such as Google glasses, according to interviewee 3/4E, would have a major effect on reducing identification times and thus response times, not only for electronical, but also all other parts. Another concept, which can be categorized in this area and which was identified through the data analysis, is the use of augmented reality applications, where for instance and also in glasses, information is shown to the user based on where he/she looks. Once a spare part is looked at for instance, this system could automatically show the details, such as the article number, of that certain part in order to quickly order or exchange it. “A mix of these concepts, or even a mix with concepts such as barcode- or RFID-identification,” would be highly beneficial to the service technician and thus the process, as stated by interviewee 2/3E. As these concepts are all fairly new still, however, the costs and efforts to implement them are comparably high.

Further technologies that could have major influences and drastically decrease response times are 3D-printing, which already exists in trial runs, according to interviewees and as observed during data analysis, and big data, which basically means to collect all the data possible and derive conclusions from it especially with respect to preventive maintenance, but also corrective maintenance, i.e. through knowledge sharing, etc.

Besides other factors, according to Baader (2014), especially the investment in these new technologies is a major trigger for quick services, however, as the traditional supply chains can be overcome. Please see **Figure 38** for an example of response time improvement through

3D-printing as provided by Baader (2014). Especially for parts, which are not on stock and are also not produced anymore, 3D-printing could eliminate the need for work arounds or long sourcing processes.

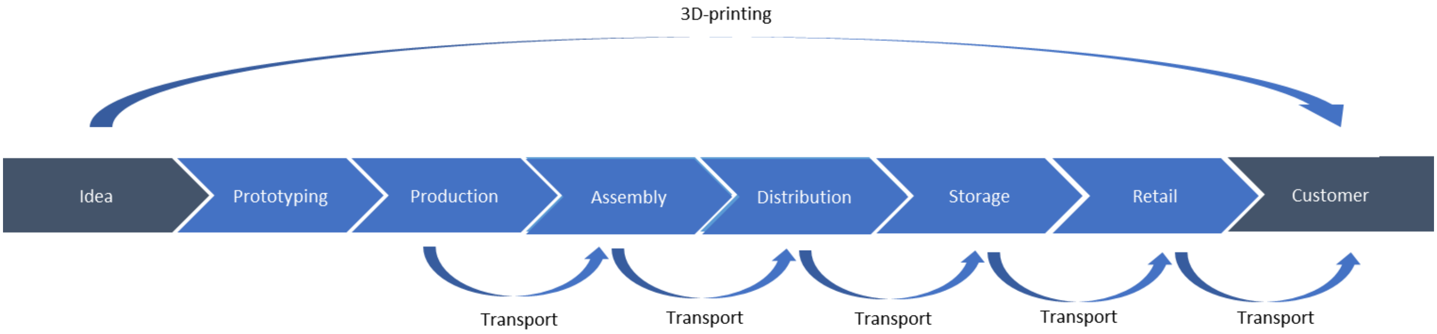


Figure 38: Improvements through 3D-printing in the supply chain (Own figure based on Baader, 2014)

If the issue and the needed spare parts have been identified, the car stock can be optimized in order to better serve the technicians. A standard portfolio with the most relevant parts should be defined based on the region of operation and specific additional parts based on the individual portfolio of the service technician should have the benefit of avoiding unnecessary ordering and first time fixes. A side effect would be the reduction of the capital employed for the company. Automatic replenishment, once a spare part is booked onto a job through the mobile device should take place. Here again, barcode- or RFID-scanning would decrease mistakes and speed up the process, according to interviewee 0/1E. If a part is not available through car stock, the mobile device should automatically show the nearest and quickest access to the spare part regardless of it being a warehouse, branch stock, other technician's car stock, etc. "If a part is completely unavailable, local purchases should be made a simple option to quickly retrieve the part", according to interviewee 5/6E.

In order to receive the parts quickly, different delivery modes should be available to all technicians, as stated by interviewee 2/3E. Direct shipments, PUDOs, overnight deliveries and express services, such as in the Netherlands, where pensioners are hired to deliver parts directly to site, etc. should be accessible to all technicians depending on the issue and the urgency.

Once the part is available through this process, the technician can also be supported through improvements while repairing the unit. Here, as stated by interviewee 4/5E, "especially repair kits, which include all the tools and parts for a certain defect, should be available." Furthermore, high quality and light tools are essential in order for the technician to be able to carry everything.

Further improvements for the overall performance and quick response time by the service technician include organizing service level agreements and approvals of service up to a certain value with all customers prior to all jobs, reacting to the growing portfolio of spare parts by specialization of the technicians as well as building platform based elevators, which all use a portfolio of standard parts. Additionally, module exchanges instead of spare parts with adjacent failure analysis in the back office, parametrization such as used by Apple to fix certain issues for a large portfolio through a cloud, having regular trainings not only for customer orientation but also technical knowledge building or refreshments, allowing for a structured and regular exchange of ideas and needs between the technicians, installing a globally used KPI to measure service response time in corrective maintenance such as in Austria and Switzerland, and installing experienced colleagues in trouble shooter or remote service positions in the back office are further improvement ideas for the process. Also, a clear communication of production stops for certain parts as well as a stable ERP-system and internet connection are essential in order to optimally support the service technicians in keeping response time in corrective maintenance to a minimum.

According to interviewee 0/1E, "it is also always essential with all improvements to never lose focus on the local specifics and to stay flexible to a certain degree." Interviewee 4/5E furthermore stated the specific importance of the service technicians themselves. He mentioned that "they are the core influence in the process and therefore their motivation, skills, customer orientation, needs, and alike are the most important factors when trying to optimize service response time in corrective maintenance." Furthermore, this experts states that "their inputs should receive a larger audience and more importance." Trainings in all kinds of different aspects, e.g. soft skills and customer focus, specialization, technical trainings, etc. should be offered regularly. In terms of safety, according to interviewee 4/5E, one other improvement could be a dead-man-function in the mobile devices, which is usually used in trains, and could be very beneficial for technicians working alone in elevator shafts to make sure they are alright at all times.

In order to comply with the need for high class service technicians, the high fluctuation in the market and the scarcity of human resources, interviewee 13/7E mentions the possibility to utilize service technicians from other business areas. Especially suitable are mechatronics, car mechanics and electro mechanics, according to this expert.

An overview of all the perceived improvement opportunities identified in the elevator business is displayed in **Table 15**. As for the factors, also for the improvement opportunities, the large amount of data will further be utilized and prioritized as part of the consensus construction development (**Chapter 4.3**).

	Solutions/improvement possibilities
1	Smart questioning manuals/instructions, e.g. perfect call descriptions
2	Service centre trainings
3	Increase remote service/assistance focus
4	Install experienced technicians in remote positions
5	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.
6	Geo-tracking
7	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit,
8	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device
9	Navigation system/GPS in every car
10	High quality diagnostic tools
11	Third-party equipment diagnostic tools
12	Image recognition software for mobile devices (such as Google glasses)
13	Augmented reality applications, that show information on parts/units
14	RFID/Scanning functions on mobile devices
15	Access units remotely through clouds
16	Online/electronical spare parts catalogs/manuals available on mobile devices
17	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices
18	3D-drawings/explosion drawings were necessary in catalog on mobile devices
19	Multiple pictures from various angles per spare part in catalog on mobile devices
20	Regular updates of catalog on mobile devices
21	Mobile device for every service technician
22	Strong IT-/ERP-support
23	Unique parts numbers that match with information in catalog on mobile devices
24	Additional information on spare parts that matches with information in catalog on mobile devices
25	RFID/Scanning functions on spare parts
26	Bill of matierial per unit
27	Easy exchange of information and pictures in chat functions on mobile devices
28	Different technicians/support levels for different issues
29	Specialization trainings
30	Regular technical trainings (knowledge building and refreshments)
31	Customer management/orientation trainings
32	Paperless approvals through mobile devices
33	Automatic car stock replenishment through mobile device bookings/statistics
34	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates
35	Automatic stock location replenishment through software
36	Mobile device should show nearest available stock location for each part
37	In emergencies, make use of parts produced for new installations (manufacturing centres)
38	Web shop for direct ordering via mobile device
39	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device
40	Paperless orders/bookings through RFID/scanning functions on mobile device
41	3D-printing
42	Clear identification/diagnosis processes
43	Allowing local purchases with easy processes in situations, where other options are not as good
44	Create a flexible delivery concept with multiple options for the technicians/customers to pick from
45	Possibility to pick up parts at warehouse, if necessary, and pre-notification through mobile devices
46	Possibility to have parts delivered to pick points/PUDOs through mobile devices
47	Forwarders with extensive network of pickpoints/PUDOs
48	Possibility to have parts delivered into cars/vans/trucks through mobile devices
49	Possibility to have parts delivered to site through mobile devices
50	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices

…

…

51	Repair kits with standard tools
52	Repair kits with standard parts for certain issues
53	High quality and light tools
54	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office
55	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device
56	Design platform based units to reduce the number of parts
57	Design module based solutions
58	Utilize/hire service technicians from other business areas
59	Monitor service technicians performance (where possible) in order to point out improvement opportunities
60	Mirror training needs with actual trainings received regularly
61	Administrative trainings
62	Softskill trainings
63	Beware of technicians' needs
64	Incorporate technicians' knowledge
65	Motivate technicians through trainings, etc.
66	Safety focus, e.g. through dead-man-function
67	Install emergency service for out-of-office times according to service level agreements
68	Install globally used KPI to measure service response time
69	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher
70	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings
71	Communicate new products/production stops to after-sales service department structured and well in advance
72	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly

Table 15: Perceived improvement opportunities identified in the elevator business area

4.2.4 Mining equipment business area

4.2.4.1 Introduction

In the mining business area, a total of seven interviews with nine interviewees were conducted between 17.07.2015 and 05.08.2015. Two interviews were conducted as joint interviews with two interviewees participating together. Out of the nine interviewees, five had an operational and four had a strategic background. Just like in the elevator business area, it was the goal to include both operational hands-on knowledge from experts in different regions as well as a strategic and global perspective on the relevance of the topic for the business. The experts from the operational side all had at least ten years of experience, most of them more than 20 or even 30 years. On the strategic side, two experts had more than five years of experience, the others more than ten respectively 20 years of experience. Both from the strategic as well as operational side, interviewees were chosen from a variety of regions and fields of operation again in order to add to the variety of perspectives in the findings. All experts interviewed thereby were in leading roles for the business or respective mining projects.

Four of the interviews were conducted personally in one-to-one settings, three interviews were conducted by telephone conference. For all interviews, handwritten notes were taken during the conversations. Four of the interviews were recorded and three interviews were not recorded based on the personal preferences of the participants. In these cases, more time was allowed for the handwritten comments and protocols in order to assure that all information was received. The average length for all interviews in this business area equaled approximately 75 minutes. Here again, this only includes the net interview time. Backwards translations, reviews, etc. are not included in this time. An overview of the interviewees from the mining equipment business area are given in **Table 16**. A summary of the key information from the interviews is displayed in **Appendix 5**.

Inter-view	Inter-viewee	Inter-viewee per BA	Date	Business Area (BA)	Position	Strategic/ Operational	Region	Base	Years of Experience	Interview Mode	Notes	Recording	Comment
6	7	1M	17.07.15	Mining equip-ment	General Manager Services	Operational	Australia	Australia	>20	Telephone Conference	x	x	
7	8	2M	20.07.15	Mining equip-ment	Head of Global Service	Strategic	Worldwide	Germany	>20	Personal	x	x	
8	9	3M	21.07.15	Mining equip-ment	Technical Service Manager	Operational	Sub-Saharan Africa	South Africa	>10	Telephone Conference	x	x	
9	10	4M	22.07.15	Mining equip-ment	Service Manager	Operational	France/North Africa/West Africa	France	>20	Telephone Conference	x	x	
10	11	5M	29.07.15	Mining equip-ment	Head of Service & Technology	Operational	Worldwide	Germany	>30	Personal	x	-	Joint Interview
10	12	6M	29.07.15	Mining equip-ment	Project Manager	Strategic	Worldwide	Germany	>5	Personal	x	-	Joint Interview
11	13	7M	03.08.15	Mining equip-ment	Commercial Manager Global Services	Strategic	Worldwide	Germany	>10	Personal	x	-	Joint Interview
11	14	8M	03.08.15	Mining equip-ment	Commercial Assistant Manager Global Services	Strategic	Worldwide	Germany	>5	Personal	x	-	Joint Interview
12	15	9M	05.08.15	Mining equip-ment	Head of Assembly & Coordination	Operational	Germany	Germany	>25	Personal	x	-	

Table 16: Overview of expert interviewees from the mining equipment business area

Besides the interviews, one process observation was conducted in a mining pit in Germany in order to add onto the findings for this case study. Available data and documents were also analyzed and used to support the findings for this case study. This data was derived through data and document bases as well as directly from the interviewees and business experts, where applicable.

The case results are displayed in the same order as in the pilot as well as the elevator business area, i.e. general information, corrective maintenance process, influencing factors, and performance improvement.

4.2.4.2 General information

Similarly to the elevator business area, also in the mining equipment business, spare parts logistics and service as well as corrective maintenance are perceived as very important for the business by the expert interviewees.

The servitization maturity level of this business area is thereby perceived to be comparably low overall, contrasting the importance of service within this industry, which is continuously increasing, according to the interviewees. Especially "a shift away from capital investments for heavy machinery towards more service related business as well as operational expenses can be seen", according to interviewee 6/1M, General Manager Services in Australia. In the Australian market, for instance, approximately 70% of the revenue share of 80 mio. AUD (Australian Dollars) order intake is generated through services nowadays. In other markets, e.g. France, Northern and Western Africa, as stated by expert interviewee 9/4M, responsible Service Manager in this region, currently only about 12 to 14 mio. Euros of service revenues are generated annually, which equals to approximately 10% compared to new equipment revenues. However, the potential is much larger, as stated by this expert and the trend towards service is increasing. Overall, the enormous potential of the service sector in the mining equipment business area can be seen from the stated company's global goals of increasing the EBIT generated through services from 400 mio. Euros in fiscal year 2014/2015 to 700 mio. Euros annually in fiscal year 2019/2020, which was mentioned by interviewees 11/7M, Commercial Manager Global Services and 11/8M, Commercial Assistant Manager Global Services.

Besides the rising importance of service for businesses, "margins are also a lot higher in service than in new equipment sales", according to interviewees 10/5M, Head of Service & Technology and 10/6M, Project Manager. Services are the solid backbone for new installation equipment as the market is much more stable and not as volatile. Additionally, services also generate follow-up business for the service providers. According to interviewee 7/2M, Head of Global Service, "it must therefore be the goal for any service provider in this business area to not only be a spare parts provider, but much rather a service provider and partner to the customer throughout the entire lifecycle of the equipment."

The importance of corrective maintenance in this business area is especially generated through the high costs involved with failing equipment. Statements vary from interviewee to interviewee and region to region, however, overall it can be seen that a broken down unit in the mining equipment business area causes the operator extremely high costs. Whilst the global average of downtime cost is numbered at 10,000 to 40,000 Euros per hour by interviewee 7/2M, averaging in a similar range to the costs in Germany of 10,000 to 50,000 Euros per hour, as mentioned by interviewees 10/5M and 10/6M, in Sub-Saharan Africa, production losses and downtimes easily average at 100,000 Euros per hour, according to interviewee 8/3M, responsible Technical Service Manager for the region. The costs for failing equipment can therefore quickly reach millions of Euros for the operators of the equipment. Extremely quick corrective maintenance therefore is essential, as stated by all experts. The larger focus, however, lies on spare parts sales, preventive maintenance and condition monitoring. Additionally, concepts such as integrated asset management or performance based schemes are frequent and common in this business area.

Overall, the company in the mining equipment business area is organized in service centres around the world. Especially in key mining markets, such as Sub-Saharan Africa and Australia, presence and closeness to the customer are essential to have quick service response times. For some customers, service centres are located right on the customer site in order to react to any disruption immediately. This, for instance, is the case of interviewee 12/9M, Head of Assembly & Coordination, who operates a team of 21 service technicians in a customer mine to prevent equipment failures and react immediately in case of sudden break-downs. In addition to the service centres close to the customer, regional hubs as well as the main sites in Germany act as supporters for technical and operational assistance, as special task forces and for general support on a global level.

In cases where corrective maintenance is required, spare parts can vary in size, dimensions and costs drastically. According to interviewee 6/1M, a spare part in this business area can be anything from a consumable weighing less than one kilogram and costing a few Euros to a 40 or 50 tons crusher, which costs up to approximately 800,000 Euros. “In materials handling, equipment can even weigh up to 300 tons”, according to interviewee 8/3M. Depending on the size and weight, transportation and logistics are generally quite complex, especially because a lot of parts in this business area are custom fit and produced only by the OEMs. Replenishment of stocks can therefore take multiple weeks.

Servicing of units can occur both on own as well as third-party equipment, making the market highly competitive. Maintenance contracts generally do not exist. Much rather, frame contracts with operators are created to clarify the circumstances and codes of operation in cases of break-downs. Furthermore, as mining equipment is extremely complex and needs trained people to operate it, usually the owners of the equipment have engineers and technicians on-site at all times, who handle lots of the issues themselves and as they learn from the service providers. In addition to that, due to the extremely high costs in case of equipment failures, lots of preventive systems get more and more common on machines, according to interviewee 12/9M, causing the machines to shut down before failures can occur and to prevent the need for corrective maintenance oftentimes.

As corrective maintenance cannot fully be eliminated in this business area as well, however, the service technician plays a major role as he or she is the face to the customer. These technicians need to be highly experienced and trained in order to supply the customer with the best and most effective service available in order to put the unit back into operation as quickly as possible, according to the interviewees.

4.2.4.3 Corrective maintenance process

In general, as seen through the interviews as well as the process observation, the corrective maintenance process in the mining equipment business area is similarly applied globally. Just like in the elevator business area, only minor local adaptations are made to react to certain circumstances based on the main process steps.

In case of units breaking down, the customer calls the service hotline of the service provider. The customer then explains the issue to an expert. In this discussion, the expert at the back office usually tries to provide remote service support and captures all the necessary information in order to send a service technician to site with the right information and material. Oftentimes, as mentioned before, due to the high level of expertise of the operator’s own engineers and technicians, an issue can be identified fairly quickly therefore, either by themselves or together with the help and guidance of the back office experts of the service provider. Remote service and/or the operators taking care of an issue themselves makes up 80 to 90% of the corrective maintenance cases, according to interviewee 7/2M. The advantage for the remaining cases and this approach is that the technicians that will go to site can generally be equipped with solid information on the situation as well as the right tooling, e.g. for diagnostics or repair as well as the right spare parts to fix the issue right away.

Due to the nature of the industry, where units are spread out in remote areas of the globe, it usually takes the service technicians that will fix the issue about one day to reach the site after they have been dispatched by the back office. The goal is to always have an expert on-site within 24 hours. Usually, experts will be flown in, either from service centres in the same country or region, or if special task forces or experts are required, from anywhere in the world. Corrective maintenance always has higher priority than other maintenance activities, as stated by the interviewees.

With the high costs involved in unit downtimes in this business area, operators usually store key parts for immediate exchange on-site. This being the case, and having the issue identified upfront, repairs and corrective maintenance can usually be handled within one day generally through the experts/service technicians sent to site.

In cases where diagnostics of the issues could not be done upfront, very experienced senior technicians will be sent to site in order to identify the issue. In these cases, as suggested by interviewee 8/3M, the main job of these experts is not only to find solutions, but especially to deal with the customer and explain the situation and plan. Logistics, contractual agreements, etc. are dealt with in the back office. The face-to-face support right away, however, is crucial for the success of the corrective maintenance, according to this expert. Here, also long-term customer relationships are extremely beneficial. It is therefore the goal to always send the same experts to the same sites, if possible, according to interviewees 10/5M and 10/6M. Besides the expertise of the technicians sent to site, the spare parts catalogue and diagnostic tools play an especially important role in order to identify issues quickly.

In cases where parts are not available after identification of the issue has been finished, and with lead times to re-order items being very long in general, provisionary solutions are oftentimes considered to get the units running again by the on-site experts. Also, a specialty in this business area is that competitors help each other out. This means that if one operator has a break-down of a unit, but not the right spare part to fix it, and re-order times are calculated to be several weeks, other operators will provide these spare parts, if they have them on stock generally. The missing parts will then be ordered through different channels and after confirmation by the customer as well as an internal risk assessment of the payment plan through the back office. In general, according to the expert interviewees and as observed during the process observation, usually whenever a certain part is exchanged, other parts are exchanged right away as well.

Until the final fixture of the unit has been finished, the on-site expert will remain with the customer to support with the temporary solutions as well as with any other issues regarding the corrective maintenance process. Overall, communication with the customer, according to the interviewees, is the key for success in this business area once it comes to corrective maintenance. The service technicians and experts in the back office therefore play a crucial role in this process.

Reasons for break-downs in general are poor maintenance and skills shortages in the operation of the mining equipment. Overloading equipment, improper handling as well as using the wrong materials can cause sudden break-downs. Wear and tear are generally not an issue, however, as preventive maintenance is far advanced in this business area with sensors, etc. usually avoiding failures to occur.

According to all interviewees, the service response time is not monitored as a KPI currently. Speed, as seen in the interviews, observation and documents analyzed is, however, the key competitive objective in this business area as well. As also observed in the elevator business area, other competitive objectives to consider include quality, flexibility, dependability, price, prevention, security, and safety. This is displayed in **Figure 39**. These results will be further utilized for the consensus construction described in **Chapter 4.3**.

Figure 39: Competitive objectives identified in the mining equipment business area (Own extended figure based on Slack et al, 2014)

4.2.4.4 Influencing factors

With regards to influencing factors, also in the mining equipment business area a multitude of factors that influence the service technicians in the corrective maintenance process was stated by the experts interviewed. Furthermore, factors were identified during the process observation and documents/data analyzed. In-depth explanations on a large number of factors are given in this chapter, before an overview of all factors is displayed in **Table 17**.

Whilst factors in the diagnosis and identification of an issue remotely and on-site as well as access and travel to site, repairing, ordering, and receiving are perceived to play a very important role in corrective maintenance, according to the interviewees, strategic factors are perceived slightly less significant by the experts, but still important. Uncalled events, etc. are perceived to have a rather low importance and influence on the response time in service with respect to the service technicians, as stated by the experts.

According to the interviewees, in the category of accessing a unit and traveling to site, especially the fact that most units are located in very remote areas and technicians usually have to fly to reach it, is a major influence on the service response time. Whenever a service centre is located within the same country of the mine, obviously response times are quicker than in cases where technicians have to be flown in from a far distant regional service centre or elsewhere in the world. The quickest response times can be generated in the cases, where the service technicians are located on-site. In these cases, language barriers and cultural differences play less of a role than whenever experts come from distant places as well. Safety as well as health or medical tests, e.g. for units in high altitudes such as the Andean mountains, as well as the acquisition of visas can also be an influence factor in this category. Usually, however, a few technicians have the relevant documents readily available for a certain set of units in order to be sent to site right away. In cases where experts have to be flown in that do not have the needed documents readily available, the approvals of visas as well as safety and health or medical certificates can increase response times by a few days or even weeks. To be known by the customer usually increases the chance of being able to quickly access the unit. Overall, planning and prioritizing, etc. are major factors in this process step, according to the interviewees.

Once on-site, in terms of diagnosis, as mentioned before, usually a lot of work has been done by the on-site technicians of the operators already. If they cannot identify the issue or parts to be exchanged, however, according to interviewee 7/2M, “the history of the unit is normally monitored and checked by the service technicians.” Since it is not allowed to modify a unit by the operator in such a way that it cannot be serviced by the service provider anymore, the data usually helps the service technicians to quickly identify the causes of the problem. In addition to that, the service technicians are usually provided with as much information as possible before going to site. The information given to them is generated through the initial calls between the customer and the service centre back office. Furthermore, electronic copies of the spare parts catalog are available to all technicians on mobile devices such as smartphones. Customers usually also have access to hardcopies as well as web shops. In addition, they also provide operating manuals and their knowledge regarding the units grows over time, thus providing a good base for the service technician to identify the issue quickly. Experience and know-how are extremely important factors in this business area. The more the technicians know, the easier it is for them to identify problems and issues quickly. Due to the size, dimensions and variety of the equipment, these aspects are critical in order to achieve quick response times and high quality service. Another important influence factor on the service technician is the availability of the right diagnostic tools to identify the issues quickly and easily.

If a service technician is unable to identify parts or issues him- or herself, however, an exchange of information and help is initiated, especially with specialists for certain systems, etc. When there is a lack of specialists for certain systems or technologies, as mentioned by interviewee 9/4M, this generally has a negative impact on the service response time, as the knowledge about the problem has to be acquired elsewhere first. Internally, as added by interviewees11/7M and 11/8M, identification of spare parts can sometimes take up to three weeks.

Once an issue has been identified, the back office immediately works out an action plan and dispatches further experts, spare parts and tools. The availability of spare parts is of key importance to the service technician in order to generate quick response times in this case. If a part is not available through the site stock of the customer or the warehouse of the service supplier, ordering increases the process drastically in general. A long approval process will then be required and multiple people will need to be involved on both party sides. In some of the countries of operation, these approval processes will still be done through facsimiles and other older technologies, e.g. in Algeria, as mentioned by interviewee 9/4M, extending the response time even more. Some equipment can be acquired fairly easily, some other equipment, however, will need to be produced first, as it is custom fit. In these cases temporary solutions will need to be worked out by the service technicians, as delivery of these parts usually takes multiple weeks.

The delivery of parts usually depends on the size and weight of the equipment and also on the freight mode the customer is willing to pay for, e.g. road versus air freight transport, etc. In general, the service technician does not have much influence on this decision. He/She is, however, highly influenced by it as he or she will then need to work out alternative methods of temporarily fixing the unit until the ordered parts arrive. In some regions, e.g. Sub-Saharan Africa, this is less of an issue, as mentioned by interviewee 8/3M. According to the expert, “here, multiple emergency vehicles with approximately 100,000 Euros worth of parts and tools are readily available to be used when needed.” Their reaction time is approximately four hours within South Africa. Added by interviewee 12/9M is the fact that the repair trucks cannot just be any kind of vehicle, but should fit the environment they are needed in. He therefore highlights the importance of jeeps to fit the requirements and support the service technicians in the best way possible. This importance could also be observed during the process observation in the mine pit.

Tooling is equally important in order for the technician to repair the unit, according to the interviewees, and as noted in the process observation. In certain regions, e.g. France as well as Northern and Western Africa, only one equipment and tooling box is available due to cost reasons. If two units were to break-down at the same time, a bottleneck is created and response times increase as the service technicians would either have to wait or have to find alternatives.

Terms and conditions and liabilities will need to be clarified upfront. Otherwise, this influences the service response times generally. Here, the technician is influenced in a way that he or she cannot operate until these details are cleared. However, these points are usually handled through the back office and not the technicians themselves. Not only in these cases, but in general, there is a major influence on the response times and the service technicians depending on the quality of the support of the back office.

If parts and tools are available on-site or through easy delivery within a few hours or the next days, the repair of the unit can be initiated quickly, according to the interviewees. For this, a good repair plan and good preparation by the entire team is required in order to have a first time fixture of the issue. The communication both with the own as well as the customer's team are extremely important for the success of the operation.

Overarching the corrective maintenance business in this industry is the fact that highly trained and experienced specialists, who are needed to conduct corrective maintenance in this business area, are very scarce in the market. "This is a factor, which is generally underestimated", as mentioned by interviewee 12/9M and thus causes bottlenecks, which then again leads to longer response times in cases of corrective maintenance needs. Simultaneously, motivation can be an extremely important factor. On the one hand, the requirements for the job as a service technician in this industry are extremely high. Knowledge and experience, as well as flexibility and dependability, the requirement to work on very remote sites under heavy weather conditions for long periods of time, etc. are crucial for this job. On the other hand, the trend towards more and more preventive maintenance and the ability of operators to fix a large number of issues themselves, causes a situation, where motivation of the few experts available is likely to be one of the most important factors to stay aware of overall.

Further strategic factors, which have an influence on the process and the technicians conducting it are the need for top management support and a general service oriented mindset of the company, strategic pricing as well as a need to react to the growing portfolio of units with increasing complexity worldwide. Factors, which cannot or cannot easily be influenced are weather conditions, such as cyclones in the Australian summer months or Canadian winters, geographical locations of units as well as the infrastructure around units, which is different in Europe than in Asia for instance or regional laws and regulations. These, as mentioned before, play a comparably little role with regards to service response time as stated by the experts during the interviews.

Overall, as mentioned by interviewee 7/2M, "when a global view on the corrective maintenance process in the mining equipment industry is applied, in the best case, responses in this business area are within one to two days, in the worst cases they take multiple weeks."

An overview of all the perceived factors identified to affect service technicians with regards to stationary equipment corrective maintenance in the community studied in the mining equipment business area is displayed in **Table 17**. As already described in the elevator business area, also here the factors have been clustered per process step as well as influence lever, i.e. strategic, operational or other/non-influenceable circumstances. The results will be used to generate the consensus construction, which is described in **Chapter 4.3**.

Influence type	Process steps	Influence factors
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information
		Offering remote help/service
		Experience/knowledge/know-how
		Pre-identification through operators/on-site technicians of customer
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)
		Technicians located on-site (direct access/little travelling)
		Prioritization of jobs/dispatching/planning
		Access to units in high security areas (safety/health tests, etc.)
		Visa requirements
		Language barriers and cultural differences
	Diagnosis (on-site)	Availability of diagnostic tools
		Availability of diagnostic intelligence structures
		Availability of high quality spare parts catalogs/manuals
		Availability of electronic devices/support
		Information on customer/unit/other information
		Expert structures to identify issues/spare parts
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)
		Availability of car stock/site stock
		Availability of stock location network with quick deliveries
		Complexity of ordering process (electronical/paperless vs. manual)
		Availability of custom made spare parts
	Receiving	Availability of different delivery options to be flexible
		Delivery to site
		Availability of express/emergency deliveries
	Repairing	Experience/knowledge/know-how
		Availability of the right (quality) tools
		First time fixes as main goal/repair plan
		Temporary/alternative solutions
		Terms/conditions/liabilities/service level agreements/contractual agreements
		Communication and exchange of information possibilities
Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician
		Number of service technicians to secure proximity to units
		Training possibilities
		Fluctuation of service technicians/scarcity of qualified technicians
		Top management attention for corrective maintenance/service oriented mindset within the company
		(Intrinsic) motivation of service technicians
Other influences	Non-influenceable circumstances	Weather conditions
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)
		Laws/regulations/customs

Table 17: Perceived influence factors identified in the mining equipment business area

4.2.4.5 Performance improvement

Just like in the elevator business area, also in the mining equipment business area, a multitude of possible optimizations and improvements to increasingly support the service technician in the corrective maintenance process were stated by the experts, and observed in the process observation and data/document analysis. These are explained in this chapter, before a full overview of all identified improvement possibilities in the mining equipment business area is provided in **Table 18**.

First and foremost, being close to the site is extremely beneficial to the response time. The larger the number of service centres, the closer the proximity to units and thus the lower the response time in corrective maintenance. Furthermore, the well-organized remote service should be strengthened even more in order to create minimum response times for the customer. To react to the need for certain documents or visas, a regulation should be put in place to make sure a certain number of technicians are always equipped with the necessary documents and visas, as mentioned by interviewees 7/2M and 8/3M. Additionally, two passports should be acquired for all service technicians. To even further improve the access to the site, “regular visits should be organized in order to strengthen the knowledge on the customer, about the site as well as the equipment”, as stated by interviewee 6/1M. In cases, where it is possible to constantly place service technicians on-site of a customer unit, this will bring the largest benefit and lowest response times in corrective maintenance.

The support of the back office is extremely important and also a major factor that affects the service technician in corrective maintenance. The information given to the technicians from the back office, as well as all the planning on logistics, ordering and sourcing of parts, contractual details, etc. should not be dealt with by the service technician. For every customer, research and preparation therefore should be done. This includes sending somebody to site to collect GPS data, create travel plans, collect information on the equipment, take care of health and safety issues, decide on logistics options, find accommodation close to site, clarify liabilities, etc. so that once a need for corrective maintenance arises, all the ground work is set up and the service technician does not need to worry and is not affected by it. Furthermore, this strengthens the customer relationship and trust level between the parties, as stated by numerous experts.

With regards to identification of issues or necessary parts, not only the customers should learn from the service providers. Usually they are extremely well informed about their equipment. This knowledge should be used for the service providers to improve themselves and their service level, i.e. service response time, accordingly. Furthermore, due to the scarcity of experts, different levels of service technicians/expert structures should be implemented and filled through training programs. Depending on the issue, which is discovered through the customer call at the call or service centre, the right expert with the right experience and knowledge should be sent to site. The decision, who will be sent to site, should be made through the back office depending on the information retrieved both in the preparatory stages as well as the customer call. Back office employees therefore need to be highly skilled and experienced as well.

To further avoid delays and support the service technician, "for corrective maintenance a fast track should be installed to avoid the normal process of inquiring three different offers for expensive material", as stated by interviewee 7/2M. Due to the urgency, in these cases the service technician together with the responsible back office experts should decide on the supplier immediately. A focus on supplier relationships needs to be implemented to have trustworthy suppliers with reasonable prices and minimum lead times for these cases. In addition to that, another option of expediting the supply of material or spare parts, a regulation should be put into practice, which will allow the utilization of parts, which were originally planned to be used for new equipment as spare parts. In most cases, according to interviewee 7/2M, this will not interfere with the delivery of the new equipment, as the production lead times are very long for these anyways.

In terms of avoiding ordering and shipping completely, emergency trucks with the most relevant spare parts and tools should be available in all strategic locations in sufficient numbers. This would drastically improve the response time and simplify the process for the service technicians. Even further, as suggested by interviewee 9/4M, "small tooling boxes with the same purpose of having the most important equipment readily available should be located in strategic locations" and should be given to traveling service technicians to avoid larger tooling sets getting stuck at customs, etc.

In order to be as efficient and quick as possible in repairing the unit, the service technicians should be trained on multiple different equipment types and all the training necessary to cope with the increasing complexity of the equipment. Furthermore, they should receive trainings in customer relationship management as well as communication skills, as they are the face and link to the customer. Knowledge created once through the use of temporary fixes, lessons learnt, etc. need to be kept and spread amongst the experts for further projects. Also, communication regarding exchange of information and help should be pushed through the use of WhatsApp groups (which is done in Sub-Saharan Africa already, according to interviewee 8/3M) or similar applications. The same should be put into practice to communicate more and use the expertise of the customers in order to quickly fix issues. The use of more sophisticated mobile devices could further improve the efficiency and effectiveness of the service technicians, especially with diagnostic software installed, all necessary information on a job readily available, for communication, paperless working, etc.

Overall, as mentioned already, especially the motivation of the service technicians needs to be strengthened, as this is a key factor to reduce response times. Preparing the technicians for the cultural changes, safe and clean places to sleep as well as all of the other side effects that should be dealt with through the back office upfront, will improve the service technicians' performance as they do not have to worry about it themselves anymore. Work-life-balance and enough time for the private life should also always be considered by the responsible managers.

Strategically, as mentioned by interviewee 7/2M, a critical mass of service is needed in order to successfully conduct it. Only with a certain volume of service contracts and jobs, service centres can be installed and experts can be hired. In this context, the availability of spare parts and tools, which binds large amounts of capital in this business area, needs to be accepted to a certain degree in order to avoid long response times and thus unhappy customers, which eventually leads to problems for the service business itself. Furthermore, preventive systems are a strategic focus point, which should be used to retrieve more information for the cases, where corrective maintenance is still needed, as stated by interviewee 12/9M. The mentioned integrated asset management concept by interviewees 11/7M and 11/8M boosts yet another opportunity to reduce downtimes and increase service response times and should therefore be tested further.

An overview of the large variety of improvement opportunities observed in this business area is provided in **Table 18**. The large amount of inputs will be further structured and prioritized as part of the consensus construction in **Chapter 4.3**.

	Solutions/improvement possibilities
1	Smart questioning manuals/instructions, e.g. perfect call descriptions
2	Service centre trainings
3	Increase remote service/assistance focus
4	Install experienced technicians in remote positions
5	Sensors/preventive software/systems with error possibility notifications
6	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.
7	Visit new customers/units to retrieve all necessary information
8	Service centres in close proximity to major service markets
9	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit,
10	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device
11	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site
12	Two passports per service technician, if necessary
13	Language/intercultural trainings
14	High quality diagnostic tools
15	Third-party equipment diagnostic tools
16	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.
17	Access units remotely through clouds
18	Online/electronical spare parts catalogs/manuals available on mobile devices
19	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices
20	3D-drawings/explosion drawings were necessary in catalog on mobile devices

…

…

21	Regular updates of catalog on mobile devices
22	Strong IT-/ERP-support
23	Unique parts numbers that match with information in catalog on mobile devices
24	Additional information on spare parts that matches with information in catalog on mobile devices
25	RFID/Scanning functions on spare parts
26	Easy exchange of information and pictures in chat functions on mobile devices
27	Different technicians/support levels for different issues
28	Specialization trainings
29	Regular technical trainings (knowledge building and refreshments)
30	Customer management/orientation trainings
31	Paperless approvals through mobile devices
32	Install fast track ordering process in urgent cases, where usually, due to the price of the spare parts, three offers would be needed
33	Clear approval processes/structures implemented
34	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates
35	In emergencies, make use of parts produced for new installations (manufacturing centres)
36	Web shop for direct ordering via mobile device
37	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device
38	Paperless orders/bookings through RFID/scanning functions on mobile device
39	Clear identification/diagnosis processes
40	Supplier relationship management for a network with quick delivery times
41	Reliable forwarders
42	Forwarders with extensive network of pickpoints/PUDOs
43	Possibility to have parts delivered to site through mobile devices
44	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices
45	Repair kits with standard tools
46	Repair kits with standard parts for certain issues
47	High quality and light tools
48	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office
49	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device
50	Agreements should be dealt with by back office and not affect service technician
51	Design module based solutions
52	Utilize/hire service technicians from other business areas
53	Mirror training needs with actual trainings received regularly
54	Softskill trainings
55	Incentivize technicians
56	Beware of technicians' needs
57	Incorporate technicians' knowledge
58	Motivate technicians through trainings, etc.
59	Safety focus, e.g. through dead-man-function
60	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher
61	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly

Table 18: Perceived improvement opportunities identified in the mining equipment business area

4.2.5 IT hardware business area

4.2.5.1 Introduction

In the IT hardware business area a total of four interviews with four interviewees were conducted between 20.11.2015 and 22.12.2015. Out of these four interviewees, one had an operational background and three had a strategic background. The mix of strategic and operational experts, just like in the other business areas, again was chosen to cover both a global and strategic viewpoint on this business area as well as to include hands-on experience and knowledge specific to the operations. To further include the variety of industries, which fall under the IT hardware business area, besides two experts from one of the major companies producing and servicing printers, one expert was chosen and interviewed from a company producing and servicing banking IT equipment, such as ATMs, etc., and one expert was chosen from a pure after-sales service provider that services IT hardware equipment in various different areas, e.g. laptops and computers, banking equipment and printers, etc. All experts had at least 25 years of business experience, some even more than 30 respective 35 years. To cover regional differences, interviewees were also chosen based on their experience in different regions.

Out of the four interviews, three were conducted in personal one-to-one settings and one interview was conducted by telephone conference. For all interviews, handwritten notes were taken. In one case, the interview was recorded. The other interviewees opted not to be recorded. In these cases, more time was allowed for the interviewer to note down the comments made by the experts and to write a protocol. The average time for the four interviews conducted was approximately 110 minutes. This again only represents the net interview time, not incorporating time needed for reviews, translations, etc. An overview of the interviewees from the IT hardware business area is displayed in **Table 19**. A summary of the key information stated by the interviewees is shown in **Appendix 6**.

Inter-view	Inter-viewee	Inter-viewee per BA	Date	Business Area (BA)	Position	Strategic/ Operational	Region	Base	Years of Experience	Interview Mode	Notes	Recording	Comment
14	17	1I	20.11.15	IT hard-ware	Senior Consultant CRM-Service-Logistics	Strategic	Worldwide	Germany	>35	Personal	x	-	
15	18	2I	07.12.15	IT hard-ware	Service Director Germany	Strategic	Germany	Germany	>25	Telephone Conference	x	x	
16	19	3I	10.12.15	IT hard-ware	Service Manager	Operational	Germany	Germany	>25	Personal	x	-	
17	20	4I	22.12.15	IT hard-ware	Post Sales Supply Chain Manager Central Region	Strategic	Germany/Austria/ Switzerland/ BeNeLux	Netherlands	>30	Personal	x	-	

Table 19: Overview of expert interviewees from the IT hardware business area

Just like in the other business area case studies, also for the IT hardware business area, one process observation and a thorough data analysis of available documents, etc. were included for this case study. Furthermore, the same structure of documenting the case study results in the four topic sections, i.e. general information, corrective maintenance process, influencing factors, performance improvement, was applied.

4.2.5.2 General information

Also in this business area, the experts claimed for spare parts logistics and service as well as for corrective maintenance as part of logistics to be perceived as very important and significant for the businesses.

First and foremost, it has to be noted that in contrast to the other two business areas looked at, within the IT hardware business area, a multitude of sub-business areas exists, ranging from laptops and desktop computers to printers, banking IT hardware and various other industries that are connected to IT, according to interviewee 14/1I, Senior Consultant CRM-Service-Logistics for an after-sales service provider with more than 35 years of business experience in various after-sales service industries. According to this interviewee, “all of the sub-business areas within the IT hardware business area have their own special circumstances”, however, in general the processes and ideas are similar for all of them. Furthermore, the interviewee states that “in IT hardware, a comparably high maturity level of servitization is predominant” in general.

The perceived importance of logistics and after-sales service thereby has numerous reasons. While interviewee 16/3I, leading Service Manager in Germany for the after-sales services and processes of one of the major printer producers/servicers worldwide, explains logistics to be a key tool to react to the trend of today’s business needs and expectations rising towards quicker and always on-time ad-hoc customer satisfaction, interviewee 17/4I, leading Post Sales Supply Chain Manager Central Region, which includes Germany, Austria, Switzerland and BeNeLux for the same company, adds that “logistics is a necessity to react towards the development of product-driven industries becoming solution-driven industries, which include after-sales services and alike.” Logistics and service logistics especially, according to him, are the supply pipe for successful operations of a company. Interviewee 14/1I adds to those facts that oftentimes after-sales technicians are the only face to the customer a company has. They can be a differentiator and through state-of-the-art services, which are based on solid logistics, they can generate high customer satisfaction, high customer loyalty and therefore not only margins through service, but also potential repurchases of equipment. These statements are also reconfirmed by interviewee 15/2I, Service Director Germany for a producer/servicer of banking IT hardware with additional experience in the after-sales service industry of printers, who states that maintenance and spare parts logistics are a main contributor to the business. Increasing competition in the after-sales market generates the need to differentiate and outstanding logistics are a very useful tool to generate customer satisfaction and thus additional benefits for the company.

The importance of logistics and after-sales services are strengthened by the statements regarding the significance of corrective maintenance as part of logistics by the interviewees. Unanimously, all interviewees state that the availability of equipment, regardless of it being computers, printers or banking IT, such as ATMs or bank statement printers, is extremely important to any operator. Failing equipment means production, opportunity or efficiency loss, customer dissatisfaction, etc. In banking IT for example, according to interviewee 15/2I, "especially in low density areas, where not a lot of ATMs are present, failure of one unit can cost the bank a lot of money, as they earn a major portion of their money through transactions." Furthermore, this experts states that if a customer is not able to use a transaction terminal, he [/she] will go to another bank." Failing laptops in offices, as another example, cost the operator companies usually multiple thousands of Euros due to employees not being able to fulfill their tasks and jobs, according to interviewee 14/1I. In printing production settings, e.g. insurances or publishers, production losses due to failing printers can even quickly rise into millions of Euros, according to interviewees 16/3I and 17/4I and as observed through the document analysis. Interviewee 17/4I adds the fact that also for small printers in non-production settings, immediate fixtures can be required, for instance with desktop printers of board members or politicians. In banking IT, due to the importance of downtime minimization therefore, every unit, according to interviewee 15/2I, which is out of order is therefore immediately reported to the management board. The interviewee adds that due to these circumstances and requirements for quick fixtures and repairs, approximately 95% of all ATMs as well as approximately 98% of all non-cash IT hardware are equipped with service maintenance contracts of a service provider. In printing, according to interviewee 16/3I, even 99% of the units within a business context (both office printers as well as production printers) have service contracts. For the after-sales service providers this means that quick response times and equipment recovery through corrective maintenance are of extremely high importance for the operators. The service providers need to react to these requirements with very efficient and effective corrective maintenance processes, according to all interviewees unanimously. According to both interviewee 14/1I as well as 17/4I, by offering these after-sales services, thus fulfilling customer demands and generating customer satisfaction, the service providers have a major differentiator towards their competitors and a source for a significant margin contributor.

A major focus area in the IT hardware after-sales service is on remote services, according to the interviewees and as observed during the process observation. Whilst this was stated to be true for all sub-business areas in this context, according to interviewee 14/1I, it is especially useful for laptops and desktop computers due to the small size and the comparably low amount of spare parts and thus error sources. Further trends in the after-sales market of IT hardware are module-based and easy to exchange spare parts for self-service, according to interviewee 17/4I. In this development, the service technician, however, still remains the last authority in order to secure high quality and quick help when complex errors occur.

Furthermore, according to interviewee 14/1I, “usually multiple service levels are available to choose from for the customer”, depending on the varying requirements of businesses. These differences can vary from full service agreements to only material contracts, where the service has to be paid and all spare parts are included, or service agreements, where only the material has to be paid and all technical assistance is included respectively. Furthermore, there are bring-in services and pick-up services, for instance for equipment that is not repaired at site but in a repair shop, e.g. small printers or laptops sometimes, and like-for-like exchanges through leasing agreements of equipment, etc. These different types of service levels are then completed through the individual service level agreements, which can vary based on the customer needs, according to interviewee 15/2I. In the banking IT hardware, for instance besides the regular maintenance intervals, corrective maintenance service levels include next day service, service response time including equipment fixtures within six hours and service response time excluding equipment repairs within four hours. In printing, according to interviewee 16/3I, the response time to be at site averages at around two hours, whilst the actual repair of the equipment then usually lasts around another 1.5 to 4 hours on average. Easy exceptions can be fixed in a few minutes and harder exceptions can last multiple days. Besides the regular business hours, which for instance in printing are 8:00 to 17:00 o’clock, additional shifts or emergency services are offered to the customers for an additional price in all sub-business areas, according to interviewee 16/3I.

The supply of spare parts is organized differently in each company and sub-business area. From the statements of the interviews it can be seen that in general the major focus in on the car stock of the service technicians in all cases. With their car stock inventory, the service technicians should have the majority of the necessary spare parts available. Besides that, according to the interviewees as well as the documents analyzed, usually regional or central warehouses, customer warehouses and pick points are the major sources to retrieve the necessary spare parts for an equipment fixture quickly. The spare parts portfolio in the IT hardware business area thereby largely consists of rather small parts, which cost anything from a few cents to multiple hundreds of Euros. In printers, according to interviewee 16/3I, some bigger parts can, however, cost up to approximately 10,000 Euros. The average part costs around 100 Euros. In banking IT, standard parts can cost up to approximately 2,000 Euros, however, also here the average cost per part is around 100 Euros. While the portfolio of different parts including consumables in printing is at around 60,000, according to interviewee 17/4I, the portfolio in laptops and PCs is much smaller, according to interviewee 14/1I. All sub-business areas in the IT hardware business area offer both services on own equipment as well as third-party equipment. Furthermore, the interviewees unanimously state that for extremely rare equipment or very important units, full functioning back-up units are available to immediately exchange the broken down unit and not risk long downtimes.

Examples of special circumstances to consider in sub-business areas that vary from the general IT hardware business area slightly, include the high security legislations and rules in banking IT, where for instance security personnel have to always be present during maintenance and always the very latest software updates have to be on the equipment in accordance with the European Central Bank, according to interviewee 15/2I. Another example in printing is the seasonality of the business, e.g. the high printing demand of insurances at the end of the year or the larger output of photo book printing companies towards Christmas, which needs to be considered in service, according to interviewee 16/3I.

4.2.5.3 Corrective maintenance process

Just like in the elevator and mining equipment industry, high level corrective maintenance process steps could be identified through the interviews and the process observation that apply to all sub-business areas and regions covered as part of the IT hardware corrective maintenance process. Minor adaptations to react to certain circumstances became visible as well, however, did not have a major impact on the general process itself.

Overall, as soon as a unit or equipment breaks down, the customer contacts the service provider for corrective maintenance, as stated by all interviewees and as observed during the observation. The customers is then automatically connected to a service or welcome centre, where they can immediately state their issues to fully trained service technicians with high experience. According to interviewee 16/3I, in the printing industry, "95% of the calls are handled by these back office service technicians."

In some cases, as stated by interviewee 17/4I, the printers automatically notify the service provider on necessary services, e.g. consumables to be refilled, etc. as part of the general maintenance process. In the first step it is the goal of the service/welcome centre experts to remotely help the customer in order for them to try to fix the issue immediately themselves. If that is not possible, the service technicians try to filter out possible reasons for the failure through questioning and forward the information to the service technician, who will be dispatched to go to site. The remote assistance or remote service process is very valuable in all IT hardware, according to the interviewees. Whilst in the printing sub-business area the current remote fixture rate is between 12 and 15% with a goal of increasing it up to 20 to 22%, according to interviewee 16/3I, especially in the laptops and PCs sub-business area, remote services and assistance are applicable and helpful, according to interviewees 14/1I and 17/4I. For the remote services, the standard equipment is usually placed within the service centre in order for the service technicians to actively look at the unit and go through the error analysis process together with the customer on the phone, according to interviewee 14/1I. This interviewee also mentions the possibility to intrude on broken units, especially in the laptops and PCs sub-business area through cloud and internet solutions, e.g. in order to remotely fix software bugs or to upload software.

If remote assistance is not enough, a service technician will be dispositioned to service the unit on-site, according to the interviewees and as seen in the observation and documents analyzed. This process is usually software-based. In the printing sub-business area, according to interviewee 16/3I, numerous factors are responsible for which technician will be sent to a certain unit. These factors include the geographical location of the unit, the response time/service level agreement, the qualification of technician required, special requirements with regards to safety or alike, office hours, driving times, lunch breaks, etc. Overall, in this sub-business area no fixed portfolio is handled by a certain service technician. Much rather, the best available service technician who can resolve the issue within the agreed service level response time will be dispatched. Back-up mechanisms are in place in case the first choice is not available. In the banking IT hardware sub-business area, service technicians contrary are equipped with a certain portfolio of units under maintenance in order to be familiar with the customers and the units, according to interviewee 15/2I. In this case again, however, automatic dispatching software will identify the service technician who should go to site and has back-ups available, in case the first choice is unavailable.

Once a technician has accepted a job through confirmation over his mobile device, e.g. smartphone, he or she will be sent all the necessary details on the customer and the unit through software support on the mobile device, according to interviewee 16/3I. This information also includes basic information such as the address and telephone numbers, where he or she can inform him-/herself more about the issue directly with the customer. While in approximately 95 to 97% of the cases, especially in the laptops and PCs sub-business area, the issue can be identified through remote assistance, according to interviewee 14/1I, in some cases the issues and errors of broken down units have to be identified on-site. This, as stated by interviewee 16/3I, is then done through optical identification, use of diagnostic tools, electronical documentation of the equipment and units, etc. as soon as the service technician has arrived at the unit. This could also be observed during the process observation. Travelling time thereby, for instance in the printing sub-business area, is monitored software-based and used for service response time calculations, according to interviewee 16/3I.

Once the issue has been identified, be it remotely upfront or on-the-job at site, the service technician will check for the availability of the necessary parts in the car stock, according to all interviewees. Whilst most of the issues generally can be fixed with the stock in the car, if parts are unavailable through the car stock, they need to be ordered in the available warehouses of the network. The networks differ from company to company, however, in general there are pick points, customer stocks, regional warehouses and central warehouses available to the technicians as stated by all experts. Usually the technician can even see the nearest stock location of a certain part through their mobile device, e.g. smart phone. “This includes car stocks of other colleagues as well”, according to interviewee 14/1I.

The ordering can also generally be done through software available on the service technicians’ mobile device, e.g. smart phone, and automatic replenishment is initiated thereby. A graphical display of the different general layers of stock availability in the printing industry can be viewed in **Figure 40**.

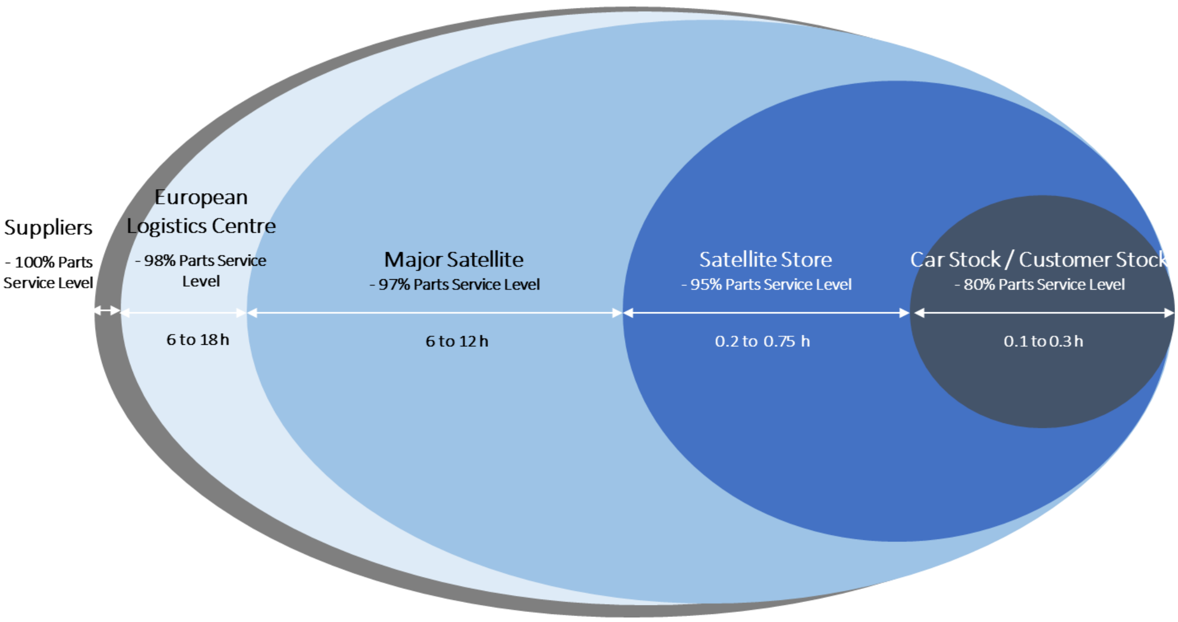


Figure 40: Layers of spare parts stock and respective service levels (Own figure based on concept explained and data provided by interviewee 14/1I)

This, according to interviewee 14/1I, is applicable as a general rule in the industry and business area. It shows that approximately 80% of the corrective maintenance jobs can be carried out with the available car stock of the technician or customer stock. Approximately 95 to 97% can be handled through satellite warehouses, which are strategically located and can be quickly accessed by the service technicians themselves or through express deliveries on the same day. Approximately 98% of the parts portfolio is covered through the central warehouse and the last two percent need to be sourced from suppliers with quick lead times. Delivery of the parts, according to the location and urgency of the service technician can then be made directly through taxi shuttles, overnight into the service technicians’ cars, to pick points and PUDOs as well as straight to customer site. In unurgent cases the general replenishment procedure, which usually happens once or twice a week will fulfill the spare parts needs of the service technicians, as stated by all interviewees.

Once all parts are available, the service technician, as observed during the entire case study, repairs the unit based on the service level agreement.

A special circumstance in the banking IT hardware sub-business area, as mentioned previously and as emphasized in this section of the interview by interviewee 15/2I again is the fact that the security regulations force the service technicians to cooperate with security personnel during all maintenance activities. Additional coordination efforts are therefore regularly present in this sub-business area.

Overall, break-downs in this business area have different root causes. As stated by the interviewees and as observed in the documents analyzed, wear and tear, mechanical, electronical and electromechanical issues can be reasons for equipment failure. Furthermore, operator mishandling on larger printers as well as laptops and PCs as stated by interviewees 16/3I respective 14/1E as well as violence on banking IT-equipment, according to interviewee 15/2I, are reasons for corrective maintenance needs.

As outlined by the interviewees, clear structures for corrective maintenance exist in the IT hardware business area and service response time is measured, however, on different levels in different companies and sub-business areas. In terms of the competitive objectives framework provided by Slack et al (2014), in this business area and the community studied therein provides additional confirmation of the importance of speed/timeliness, quality, price, flexibility and dependability, as well as prevention and safety. Furthermore, security shows to be of particular importance in IT hardware. An overview is displayed in **Figure 41**. These results are further utilized as part of the consensus construction in **Chapter 4.3**.

Figure 41: Competitive objectives identified in the IT hardware business area (Own extended figure based on Slack et al, 2014)

4.2.5.4 Influencing factors

Just like in the elevator as well as mining business areas, also in the IT hardware business area a large variety of factors exists, which influences service technicians with respect to the response time in corrective maintenance. Insights are detailed in this chapter, before **Table 20** provides a full overview of all identified factors in this business area.

Whilst factors especially in parts reception and parts and issues identification/diagnosis remotely and on-site are perceived to be the most important, generally also the factors of accessing/driving to the unit, repairing the unit, and ordering are perceived as very important with regards to the influence on service technicians and the response time in corrective maintenance, according to the interviewees. Strategic factors are seen as important as well. Contrary, the importance of non-influenceable circumstances is perceived as very low.

A major influence that triggers the response time in this business area is the quality of the remote service and remote assistance, according to the interviewees. The better the remote services are handled, the better the service can be conducted by the dispatched service technicians. Information on the issue can be given to the service technician that may help him/her to quickly find the problem, to bring the right equipment and spare parts and fix the problem on the first instance.

With regards to driving and accessing the site, according to interviewee 14/1I as well as the process observation and data analysis, obviously the proximity of the service technician to the respective site has a very large influence. Service technicians, who are permanently located at a certain site, e.g. large office headquarter, airport, etc. will have comparably low response times with respect to reaching a certain unit. They do not need to drive, they do not have a chance of getting stuck in traffic jams, they know their way to the units, they have all the relevant security requirements and approvals, etc. Especially in areas with a low amount of units, e.g. in rural areas or remote places such as islands, driving to and accessing the units can majorly influence the response time. Planning, scheduling, prioritization and dispatching of jobs and service technicians in this business area is mainly done software based.

In banking, as mentioned before, the special need to always have security personnel available when conducting maintenance is re-emphasized in this context by interviewee 15/2I. “Without security personnel, the service technicians cannot access sites or conduct maintenance.” Organizing this and arranging appointments can often cause delays in response time.

Diagnosis and identification of an issue or a part to be exchanged can influence the service technician in the endeavor to quickly repair equipment and achieve first time fixes as well, as stated by interviewee 17/4I. In addition to the information generated through remote calls, especially the availability of diagnostic tools, mobile devices with information on the unit, the quality of service manuals as well as the availability of second level support, experts to ask for help and the possibility to quickly exchange questions and information with colleagues is important, according to the experts. Furthermore, the possibility to fully exchange a unit with a back-up can drastically reduce response times, as the actual error or defective part can be detected later on without affecting the response time and thus downtime of customer equipment. Catalogs, as stated by interviewee 14/1I, in this context have less of an importance, as the service technicians usually have access to the service manuals of a respective unit, either on the unit itself or on their mobile devices.

As soon as the issue is identified, especially the availability of spare parts is important in order for the service technician to fix the unit quickly. Therefore, according to the interviewees and the process observation, the stock available in the service technicians’ cars has a very high influence. If parts are unavailable in the car stock, the structure of the spare parts supply network, where strategically located warehouses and pick points as well as the possibility for emergency delivery of parts on the same day or overnight, is a major influence on the process and the service technician. Furthermore, according to interviewee 15/2I, if specially trained technicians are required, e.g. for software issues, delays can be caused.

According to interviewee 16/3I, “the repair of the unit itself usually costs the most time in corrective maintenance in IT hardware and is therefore of key importance.” Factors related to the service technician in this context are especially the level of experience and training as well as the right tooling. Interviewee 14/1I adds the importance of maintaining a level of knowledge also for new equipment, product launches and alternative spare parts in order to have an advantage and quickly repair units. Furthermore, information such as expected mean time between failures and other pro-active measurements are important for the service technician to reduce downtimes. Another factor in the process is data security, which is especially important for certain businesses, e.g. insurances, as stated by interviewee 16/3I. To cope with the requirements, especially when security relevant software or hardware such as hard disks, etc. with personal or company specific data sets needs to be exchanged, service technicians need to be trained and know these requirements in order to avoid mistakes and problems, which can delay response times.

Overall, according to interviewee 15/2I, "the major influence on the corrective maintenance process and the response time is the service technician." With a knowledgeable and experienced service technician, who understands customer requirements, has good soft skills and is motivated, low response times in corrective maintenance are always possible. Added onto this, expert interviewee 14/1I mentions the support of the technician through technology. He states that the quality of the information on the mobile devices or the ERP-systems available can be of tremendous benefit and advantage to the technicians. If not available, however, major disadvantages for the service technician might be created. This could also be seen during the process observation.

The more information is available to the technician and the more precise it is for the job to be conducted, the more efficient the technicians can use their knowledge and skill level to quickly fix a broken down unit. Mobile devices, according to the expert should therefore include information on the job, on the unit and on the customer, paperless working should be enforced, quick communication should be facilitated in approval- as well as information exchange-processes, GPS can be used for quick access to units, spare parts ordering and booking can be done through scanning functions, automatic replenishment processes should be included, stock levels should be shown, etc. in order to optimally support the technicians and let them focus on their job, which is to quickly react to a service need and to put the respective unit back into operation.

Strategic factors, which have an influence on the technicians in corrective maintenance response time, according to the interviewees, include the service capacity of a company, meaning the number of calls and jobs per hour or day and likewise the amount of service technicians available, the quality and requirements agreed in the service level agreements with the customers, fluctuation, agreements regarding out-of-office times, e.g. weekends, holidays, nighttime, etc. Furthermore, the level of car stocks, the focus towards a strategy of service importance, the knowledge that the technician is the face to the customer and the strategic question on how good equipment should be and whether or not it is built to never fail are further influence factors on the technician in the corrective maintenance response time.

Indirect factors, which, according to the interviewees, have very low influence on the process as mentioned before, include traffic jams, weather conditions or large factories and buildings with spread out unit portfolios.

An overview of all the perceived factors affecting service technicians in stationary equipment corrective maintenance response time in the community studied in IT hardware is displayed in **Table 20**. As previously described for the other two business areas, the influence factors are thereby clustered per process step and influence lever and will further be used in order to generate a consensus construction for the community studied (**Chapter 4.3**).

Influence type	Process steps	Influence factors
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information
		Offering remote help/service
		Experience/knowledge/know-how
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)
		Technicians located on-site (direct access/little travelling)
		Prioritization of jobs/dispatching/planning
		Routing/scheduling
		Availability of facility management/(security) personnel on-site
		Access to units in high security areas (safety/health tests, etc.)
		Cars not equipped with navigation systems/GPS
	Diagnosis (on-site)	Availability of diagnostic tools
		Availability of diagnostic intelligence structures
		Availability of high quality spare parts catalogs/manuals
		Availability of electronic devices/support
		Information/barcodes/RFID/scanning functions on spare parts
		Information on customer/unit/other information
		Expert structures to identify issues/spare parts
		Experience/knowledge/know-how
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)
		Availability of car stock/site stock
		Availability of stock location network with quick deliveries
		Complexity of ordering process (electronical/paperless vs. manual)
		Ordering the right part(s)
	Receiving	Availability of different delivery options to be flexible
		Pick up of spare parts at warehouse
		Delivery to pickpoints/PUDOs
		Delivery to service technicians' vans/cars/trucks
		Delivery to site
		Availability of express/emergency deliveries
	Repairing	Experience/knowledge/know-how
		Availability of the right (quality) tools
		First time fixes as main goal/repair plan
		Temporary/alternative solutions
		Terms/conditions/liabilities/service level agreements/contractual agreements
		Module based exchange of parts
		Communication and exchange of information possibilities
Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician
		Number of service technicians to secure proximity to units
		Training possibilities
		Fluctuation of service technicians/scarcity of qualified technicians
		Out-of-office times
		Top management attention for corrective maintenance/service oriented mindset within the company
		Keeping up to pace with market trends
		(Intrinsic) motivation of service technicians
Other influences	Non-influencable circumstances	Traffic jams
		Weather conditions
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)

Table 20: Perceived influence factors identified in the IT hardware business area

4.2.5.5 Performance improvement

Also in this business area, a large variety of further optimization potential exists in order to reduce influences on the service technicians and thus response times and downtimes of equipment in corrective maintenance. A selection is displayed in this chapter, before a summary of all identified improvement possibilities is displayed in **Table 21**.

First and foremost, according to interviewee 14/1I, “the service technician has to be part of the solution, not part of the problem.” This means that he or she needs to be enabled to fix the issues in corrective maintenance with the first approach in order to satisfy the customer. If the technician is unable to fix the issue right away, waiting times and longer downtimes of the equipment are the result for the customer, which generates dissatisfaction. This needs to be avoided at all costs, also for the service provider itself, as it causes higher costs and less profits on the job generally.

In order to enable the service technician optimally, he or she needs to be trained and informed regularly. Also, technicians have to be prepared in correspondence to newly arising trends, e.g. the change of printers mainly operating mechanically and electronically towards software based solutions, which require completely different knowledge. Training matrices with clear structures and training needs per person, as suggested by interviewee 17/4I, could be beneficial. An exchange of information, such as suggested by interviewee 16/3I, who states the availability of a knowledge data base, which can be accessed through PCs and laptops or mobile devices and which includes tips and tricks on fixing certain issues, special causes, etc. and which enables technicians to rank the comments in order to show more meaningful hints first when searching for problems. Internal communication platforms for quick exchanges of help and ideas, which can be used on mobile devices are another improvement opportunity to help service technicians as stated by this interviewee.

In order to make the most of the opportunity of remote assistance and service, highly knowledgeable technicians need to be trained to fulfill this task. Additionally, helping guidelines such as ideal call descriptions should be prepared and provided to the call centre technicians in order for them to retrieve the required information to be forwarded to the dispatched service technician or to remotely fulfill the service themselves. Furthermore, as stated by interviewee 15/2I, if not all information could be retrieved through the initial phone call, the dispatched technicians need to be enabled to call the customers or contacts before the drive to the unit in order to maximize the chance for a first time fix.

If possible, the service technician should be provided with state-of-the-art mobile devices and software that fully supports the corrective maintenance process including paperless working, information on jobs, units and customers, communication, information exchange and approval processes, identification through service manuals and catalogs, ordering of parts and tools as well as bookkeeping through scanning, etc.

If possible and depending on a company's and region's laws and regulations, collecting data on the service technicians could also improve the corrective maintenance process and the service technicians themselves. According to interviewee 15/2I, service providers should therefore analyse service technicians in three core areas with equal influence on the process: product know-how/technical skills, soft skills and administrative skills. Product know-how/technical skills, according to the interviewee, are the easiest to learn, soft skills and administrative skills, however, being equally important. Soft skill in this context include customer management, planning and interaction, representation of the company, self-organization, etc. Administrative skills include proper documentation, bookkeeping, analysis, utilization of spare parts, according to the processes, etc. With this data, a baseline can be generated for service provider companies to train their employees, i.e. service technicians, in order to optimally create competitive advantages. Further data that should be collected, if possible, according to interviewee 15/2 includes sick days, number of units serviced in a certain time period, amount of revenues generated, etc. in order to compare and trigger high class and high quality performance. If standards and KPIs are not fulfilled, the company thus has the chance to react and speak to the service technician in order to improve the performance. Also, this boosts a chance of generating improvement potentials from the service technician, e.g. tooling requirements, car stock portfolio, language barriers, etc. in order to align strategic and operational goals. Especially the know-how of the technicians is very valuable for service providers, however, often not (fully) used, according to interviewee 16/3I.

The dispatching software should also make use of as much information as possible, depending on the company's requirements in order to send the best suited technician to a particular job. Information for the dispatching software thus should include required skills levels, availability of technicians, geographical location of the unit and the technician, service level agreements, etc., according to the experts. Also, the different approaches, either of fixed portfolios per technician versus not fixed portfolios should be integrated in the software in order to find the optimal service technician per job. According to interviewee 14/1I, "a balance between geographical and routing optimization as well as knowledge, skill level and experience of a technician has to be managed in order to comply to service level agreements and quality standards optimally."

Early ordering of spare parts and automatic replenishment of car stocks can minimize response times in corrective maintenance once the right service technician has been dispatched to a particular job. Furthermore, constant car stock optimization should be implemented in order to avoid multiple drives to units as much as possible, according to the experts. As stated by interviewee 14/1I, besides a core portfolio of frequently used parts, the portfolio obviously needs to include specific parts based on the equipment serviced, e.g. small desktop printers versus large production printers.

Delivery of parts needs to be flexible, according to the urgency and service level agreements. If needed immediately, parts should be delivered right away, whilst when service level agreements allow more time, overnight or regular replenishment should be available to the service technicians. According to the interviewees, also technicians should be able to choose the pick-up location of a needed part, e.g. a PUDO, pick point, car stock or customer site.

Once the technician is ready to repair the unit, according to the interviewees, improvement opportunities in this context include module-based solutions for easy exchanges as well as back-up systems to exchange full units and repair the broken down equipment later on in a repair centre, for instance. Furthermore, measurements of how often parts or modules break, mean time between failures as well as technical advancements such as error storages that can be read with diagnostic equipment and software are valuable preventive maintenance tools to highly decrease identification and repair times through the minimization of corrective maintenance in total.

Further important improvement opportunities include the focus on low fluctuation in service technicians, as stated by both interviewees 15/2I and 17/4I, by incentivizing and allowing for specialization, etc. Highly skilled technicians, especially when they fulfill requirements in all three aspects (product know-how/technical skills, soft skills and administrative skills), are a differentiator and should be motivated in order to stay within the company. Furthermore, as stated by interviewee 14/1I, “the use of customer feedback can have an impact on service response times”, as it enables the service providers to improve their corrective maintenance processes based on the feedback retrieved and thus improve customer satisfaction.

Last but not least, according to the experts, future trends such as Industry 4.0, 3D-printing, cloud systems, sensors in equipment and other technical developments and trends need to constantly be monitored in order to prepare and support service technicians optimally, according to interviewee 14/1I and 16/3I.

An overview of all the perceived improvement opportunities identified in the IT hardware business area is displayed in **Table 21**. The large amount of inputs will be utilized and prioritized in order to further reduce the data as part of the consensus construction, which is explained in **Chapter 4.3**.

	Solutions/improvement possibilities
1	Smart questioning manuals/instructions, e.g. perfect call descriptions
2	Back-up equipment of certain units/parts to support in error identification remotely
3	Increase remote service/assistance focus
4	Install experienced technicians in remote positions
5	Sensors/preventive software/systems with error possibility notifications
6	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.
7	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit,
8	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device
9	Navigation system/GPS in every car
10	High quality diagnostic tools
11	Third-party equipment diagnostic tools
12	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.
13	Access units remotely through clouds
14	Online/electronical spare parts catalogs/manuals available on mobile devices
15	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices
16	3D-drawings/explosion drawings were necessary in catalog on mobile devices
17	Multiple pictures from various angles per spare part in catalog on mobile devices
18	Regular updates of catalog on mobile devices
19	Mobile device for every service technician
20	Strong IT-/ERP-support
21	Unique parts numbers that match with information in catalog on mobile devices
22	Additional information on spare parts that matches with information in catalog on mobile devices
23	RFID/Scanning functions on spare parts
24	Bill of matierial per unit
25	Easy exchange of information and pictures in chat functions on mobile devices
26	Different technicians/support levels for different issues
27	Specialization trainings
28	Regular technical trainings (knowledge building and refreshments)
29	Customer management/orientation trainings
30	Paperless approvals through mobile devices
31	Automatic car stock replenishment through mobile device bookings/statistics
32	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates
33	Automatic stock location replenishment through software
34	Mobile device should show nearest available stock location for each part
35	Web shop for direct ordering via mobile device
36	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device
37	Paperless orders/bookings through RFID/scanning functions on mobile device
38	Clear identification/diagnosis processes
39	Supplier relationship management for a network with quick delivery times
40	Create a flexible delivery concept with multiple options for the technicians/customers to pick from
41	Possibility to have parts delivered to pick points/PUDOs through mobile devices
42	Forwarders with extensive network of pickpoints/PUDOs
43	Possibility to have parts delivered into cars/vans/trucks through mobile devices
44	Possibility to have parts delivered to site through mobile devices
45	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices
46	Repair kits with standard tools
47	Repair kits with standard parts for certain issues
48	High quality and light tools
49	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office
50	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device

…

…

51	Design platform based units to reduce the number of parts
52	Monitor service technicians performance (where possible) in order to point out improvement opportunities
53	Mirror training needs with actual trainings received regularly
54	Administrative trainings
55	Softskill trainings
56	Incentivize technicians
57	Beware of technicians' needs
58	Incorporate technicians' knowledge
59	Motivate technicians through trainings, etc.
60	Safety focus, e.g. through dead-man-function
61	Install emergency service for out-of-office times according to service level agreements
62	Install globally used KPI to measure service response time
63	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher
64	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings
65	Communicate new products/production stops to after-sales service department structured and well in advance
66	Make use of and monitor customer feedback
67	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly

Table 21: Perceived improvement opportunities identified in the IT hardware business area

4.3 Phase 3: Analysis, interpretation and consensus construction development

4.3.1 Introduction

As displayed in **Figure 28** and introduced in **Chapter 3.4.2.4**, this chapter deals with the analysis and interpretation of the case studies and the data generated, as well as the consensus construction development. The results displayed in **Chapter 4.2** are thereby analysed and interpreted in a stepwise approach, addressing each of the four research questions and research objectives. As with every phase in the authors research, the results of this phase have been cross-checked and validated by the two university supervisors as well as the business experts involved in this research.

This chapter is subdivided into six sub-chapters, with this introduction being the first. The second sub-chapter provides an overview of the methodological approach. Followed by this are four chapters that each address one of the research questions and objectives. In detail, the third sub-chapter of this chapter covers the analysis and interpretation on competitive objectives in corrective maintenance, the fourth subdivision focusses on factors affecting service technicians in stationary equipment corrective maintenance response time, and the fifth displays the analysis on improvement potentials. In the sixth sub-chapter, the consensus construction development is explained based on the conducted analyses in the previous chapters. This also includes and describes application recommendations.

4.3.2 Methodological approach

Chapter 4.2 provides an overview of the large amounts of data generated. Saturation of data, which provides robust and valid research outcomes/data, as described by authors such as Glaser et al (1967), Mason (2010), Baker et al (2012) and Fusch et al (2015), has thereby been observed by the author. While in the first case, i.e. elevator, all competitive objectives identified in literature (**Figure 10**) as well as three additional competitive objectives were identified, these eight objectives were also identified in the second case, i.e. mining equipment. No additional relevant objectives were observed in this case. In the third case, i.e. IT hardware, these eight competitive objectives were identified as well. Here again, no other additional objective was identified.

Similar developments throughout the cases could be observed for perceived factors affecting service technicians as well as perceived improvement opportunities as well. In the elevator business area, a total of 51 influence factors as well as 72 improvement opportunities were identified. These, as this was the first case, were all new to the context. For the mining equipment case, a total of 35 influence factors and 61 improvement opportunities could be identified. Four of the influence factors and eight of the improvement opportunities had not been observed in the elevator case previously, and were therefore new to the context. For the IT hardware case, finally, a total of 47 influence factors as well as 67 improvement opportunities were identified. Out of these, none added a new influence factor and only two entirely new improvement opportunities, which had not been mentioned in one of the two previous cases, were observed. On a more granular level, similar developments could be observed during the progression from one in-depth interview to the next in-depth interview.

Overall, the author thereby agrees with Mason (2010), who as previously stated, describes that full saturation is likely never to be achieved, as additional cases or experts may always add something new to the context. However, due to the marginality of these additional contributions at a certain point during the research, where the majority of information has been generated, and which could be observed during this research as outlined above, the author feels comfortable to have generated valid and robust data to be utilized to answer the research questions, fulfill the research objectives and thereby contribute both to knowledge and business practice.

Therefore now, in order to generate meaning from the results displayed in the previous chapter, each of the four research questions and research objectives (see **Table 2** or below) is addressed individually and in more detail in this chapter.

To recall the aim of this work, by answering the four research questions and fulfilling the according research objectives, a consensus construction to understand and improve factors affecting the service technicians' performance in terms of service response time in corrective maintenance for stationary equipment shall be developed for the community studied. The research questions and research objectives addressed in this context are:

1. What are the competitive objectives for stationary equipment corrective maintenance processes within the different business areas, i.e. elevator, mining equipment and IT hardware, they serve and how do they impact service response time?

By answering this research question, it is the goal to add clarification and knowledge around the competitive objectives in stationary equipment corrective maintenance, to address in more detail the competitive objectives besides timeliness/speed and their effect on it, to identify similarities and differences across different business areas and to identify, if additional competitive objectives may be applicable in this context and thus need to be added to the frameworks available in literature.

2. In the corrective maintenance processes in the three business areas described, what factors are perceived as affecting the service technicians' response time performance?

Given the identified importance to constantly optimize response times and speed in corrective maintenance to react to broken down units, with this step it is the aim to specifically identify factors that are perceived to have an impact on the service technicians' service response time in the different business areas and thus influence the objective of timeliness/speed negatively.

3. What is the perception towards how the process can be altered to better serve the service technicians' needs, i.e. to minimize response times in corrective maintenance?

With the perceived factors influencing the service response time in stationary equipment corrective maintenance in the different business areas identified in the previous question, this question aims at identifying potential process alteration opportunities that are perceived to improve the service technicians' needs, i.e. to minimize response times in corrective maintenance and thus improve the objective of timeliness/speed.

4. How can a consensus construction be developed in order to identify what needs to be taken into account to introduce these alterations in business practice?

With the generated input in terms of competitive objectives, perceived influence factors on service technicians in stationary equipment corrective maintenance response time processes as well as perceived improvement opportunities, it is the aim to provide a consensus construction that demonstrates what needs to be taken into account to introduce these findings in business practice in the community studied. Furthermore, it is the intention with this construct to build a baseline for further research.

Overall, it is the intention of this phase of the research to connect the existing concepts in literature and add meaningful knowledge to them through the empirical research conducted. The framework developed for the literature review (**Figure 23** respectively **Figure 24**) is therefore used as a baseline and added onto during the course of this chapter.

Thereby, cross-case synthesis, as described by Yin (2014) is therefore applied to look at the three cases conducted in detail and depth, compare them and derive meanings for the community studied based on the triangulated data displayed in **Chapter 4.2**. Further tactics applied in order to generate meaning, as described by Miles et al (2014), include noting patterns and themes, comparing and showing contrasts, identifying relationships between variables and building logical chains of evidence. Data and information is thereby further reduced and displayed in a concise matter, in accordance with Miles et al (2014). Relevant information identified throughout the continuous literature screening are added to the context, where appropriate. The approach utilized aims at generating robust and valid outcomes.

Finally, a consensus construct for the community studied is developed in this phase based on the outcomes described. This construct shall serve as a baseline for further research as well as a tool to be utilized in business practice. As in the previous phases, also here the results are validated and cross-checked both by the university supervisors as well as the mentors from the three business areas.

4.3.3 Competitive objectives in corrective maintenance for stationary equipment

Through the empirical analyses in the three different business areas, i.e. elevator, mining equipment and IT hardware, customer satisfaction was clearly confirmed to be a key parameter to consider in after-sales services, spare parts logistics, and specifically corrective maintenance for stationary equipment.

As services and after-sales activities become more and more important for companies in all product-driven industries and especially in B2B market environments, a satisfied customer has the potential to generate further margins for the same services in the future and is less likely to switch to a competitor. Additionally, satisfied customers are likely to generate spillover effects to new equipment purchases when they are satisfied with the services of a provider and they will spread positive feedback to other potential customers of service providers. State-of-the-art and above-average services from service providers, i.e. corrective maintenance processes, are therefore a major differentiator in the very competitive after-sales industries. A focus on customer satisfaction in corrective maintenance thus helps the service provider to generate competitive advantages, as suggested in Porter's (1985) model.

With customer satisfaction confirmed to be the main focus point in corrective maintenance for stationary equipment, the three cases additionally confirmed the importance of the five competitive objectives stated in Slack et al's (2014) model unanimously. These namely are speed/timeliness, cost, flexibility, quality and dependability. In addition to these five objectives, three further competitive objectives relevant for the community studied could be identified, however, providing a contribution to knowledge. In the community studied, prevention, safety and security were named to be important in order to create customer satisfaction and thus a differentiator to become/remain competitive. An overview is displayed in **Figure 42**.

Figure 42: Competitive objectives in relation to the stationary equipment corrective maintenance in the community studied (Own extended figure based on Slack et al, 2014)

When looking at corrective maintenance for stationary equipment and satisfying the customer through outstanding processes, out of the eight competitive objectives identified to be relevant for the community studied in total, speed/timeliness was confirmed as the major objective to be focused on. Customers, regardless of the business area of operation, need their units running, e.g. in production and other processes, or to comply with their customer demands. Units, which are out of operation generally create high margin losses, costs and dissatisfaction. In order to quickly reset or repair units therefore, quick corrective maintenance and response times have proven to be essential in all three cases. Response times are thereby affected by service level agreements between the service provider and the owner of equipment, however. These generally need to be complied with in order to create customer satisfaction. When agreed service times can even be over-fulfilled, this has a positive effect on the customer satisfaction, of course.

Besides the general need to respond to broken down equipment quickly in order to satisfy the customer, when keeping in mind service level agreements that allow the service provider not to send a service technician to site immediately, quick response times nonetheless mean to react to a customer need as quickly as possible. The three cases showed that when the customer notices that the service provider is taking care of their issue, e.g. by answering and responding to phone calls, by having the service technician or back office call for upfront information, by assuring that the corrective maintenance process has been initialized and help is on its way, etc. regardless of when it will actually happen based on the service level agreement, a major contribution to customer satisfaction can be realized by the service provider already.

Besides speed/timeliness, another key competitive objective for service providers is quality, as seen in all three cases. Whilst response times should be as quick as possible, this is only true as long as the quality of the job is high. A unit that breaks down oftentimes in short intervals, because faults have not fully been identified or fixed, etc. will not generate a satisfied customer, even though they might be fixed quickly each time. The service providers, and in this case, the service technicians, thus need to make sure that besides focusing on quick response times and complying with service level agreements, the quality of the corrective maintenance remains high and sustainable. In this context, tools such as SERVQUAL (Parasuraman et al, 1988), which have been introduced in the literature review, may be used to support assurance of high quality in the corrective maintenance process by making this abstract objective measureable.

The third important objective to consider in order to hit generate customer satisfaction is for the service providers to be flexible, as seen in all three case studies. This means that if urgent needs for corrective maintenance are required in an ad-hoc setting, e.g. people stuck on an elevator, schedules and plans need to be adjusted accordingly, always in order to accommodate all needs in the best possible way and according to the service level agreements. This goes hand-in-hand with the fourth important objective for service providers, i.e. dependability. Customers highly value dependable and reliable services. Only dependable service providers will have the opportunity to fully generate customer satisfaction.

The fifth of the eighth important objectives for service providers in corrective maintenance in stationary equipment with respect to customer satisfaction to consider is the costs. The cases showed that the more urgent a need for corrective maintenance is, the more expensive it usually gets for the service provider and sometimes also the customer depending on the service contract and the included services, especially as these ad-hoc needs cannot be planned and scheduled.

Once it gets more expensive, both the customer satisfaction as well as the service provider satisfaction decrease. For a service provider, and especially service technicians assigned to a job, it is therefore important to have the costs in mind in corrective maintenance at all times. This means for example to avoid unnecessary travelling, e.g. when a colleague is located closer to the unit, bringing the right equipment and spare parts to fix the unit on the first trial to avoid double driving/travelling and longer downtimes, etc. Scheduling and planning the jobs upfront can also have a high impact on the costs. Especially in the mining equipment industry, where equipment is usually located in remote places, the right experts and right equipment as well as parts should be transported to site by the service technicians straight away to avoid extra costs and downtimes. Proper scheduling and planning also help the service technicians to hit the service level agreements with the respective customers. When a service level of e.g. 95% is contracted with the customer, capacities should be utilized to hit this target and not over exceed it by trying to achieve 98% or even 100%, for instance, thus keeping costs at a minimum. As these cost saving mainly benefit the service providers by generating the highest possible margins, indirectly they also benefit the customers, as the service providers might be able to offer more competitive pricing in the favor of the customers when saving costs themselves.

One of the additional key competitive objectives to keep in mind, and as identified through all three cases, is prevention. Whilst it has been observed that non-failing equipment cannot be achieved in full, and corrective maintenance is therefore always needed, preventive measures should be focused on by the service providers nonetheless. Examples here that have a beneficial influence customer satisfaction include the use of condition monitoring devices within a unit that show the need for maintenance, for example. As the service can then be scheduled, corrective maintenance itself is less likely to be needed and higher availability of equipment will be ensured. Furthermore, software that stores error codes, etc. and which can be read remotely in a back office, for instance, will give the service technicians on-site the source of error right away and make sure he or she brings the right parts and tools to fix the unit as quickly as possible. Prevention additionally means the possibility to exchange certain parts or consumables while maintenance is being conducted on another part to prevent multiple downtimes of equipment. While this will be more expensive upfront, as parts might not have reached their final lifecycle phase, in the long run costs can be saved both for the service provider and the customer as additional break-downs and thus needs for corrective maintenance can be minimized.

Safety has also been mentioned in all three cases to be another major objective with respect to corrective maintenance for stationary equipment. Whilst it was seen that this is especially true for the elevator business area, safety both for the operators and users as well as the service technicians has top priority in all business areas. In the elevator business area, this is especially true as people getting trapped in a broken down unit are more common than people's safety being affected through malfunctioning equipment in other business areas, e.g. mining equipment and IT hardware in this case. If the safety of a person is influenced due to a broken down unit, this in all cases and regardless of service level agreements, always has the highest possible priority in all business areas, however.

The final competitive objective identified through the case studies to be relevant for the community studied is security. This was specifically mentioned in the IT hardware sub-business area of banking IT hardware, where service providers and especially service technicians are confronted with large amounts of money, e.g. during an ATM maintenance. Here, security personnel needs to be present at all times. Whilst the importance of security was particularly highlighted in this case, it was also seen as important throughout the case studies in total. In the remainder of the IT hardware business area, security was mentioned with regards to data security, and in the elevator and mining equipment industry, security in terms of access to units, e.g. key boxes, permits, security checks, etc. were named.

Overall, for the community studied it was observed throughout the empirical research that the eight objectives that influence the main parameter of customer satisfaction need to be focused on regardless of the business area, i.e. elevator, mining equipment, and IT hardware, and in the respective stationary equipment corrective maintenance processes. By adding three competitive objectives for the community studied to the framework provided by Slack et al (2014), this adjustment can be included in the framework generated as part of the literature review (**Figure 23** respectively **Figure 24**). This is displayed in an extract in **Figure 43**.

Furthermore thereby, as literature suggests and as displayed in **Chapter 2.2.1**, by focusing on one the competitive objectives, trade-offs for the other competitive objectives may occur (e.g. Skinner, 1969; Lapré et al, 2004, Avella et al, 2011; Schroeder et al,2011; Slack et al, 2014).

As observed during the empirical case study research as well as the literature review, the main competitive objective in the concept of corrective maintenance for stationary equipment thereby is speed/timelines, i.e. response time. If applying the sand cone model as described by Ferdows et al (1990) as well as Slack et al (2014), in order to avoid/minimize trade-offs between the competitive objectives, this suggests that quality and dependability have to be focused on first in order to then improve speed/timeliness. Flexibility and cost are focused on after improvements in speed/timeliness have been achieved.

If the focus approach, as described by Slack et al (2014), is applied in order to minimize the risk of trade-offs, for the community studied the main focus is also on speed/timeliness, i.e. response times. Here, a more individual focus on the specific needs per business area or even different company or sub-business area, i.e. in IT hardware, can be applied, however, which includes the additionally identified competitive objectives, i.e. safety, security and prevention. This is important, as specific needs of the various business areas are then addressed. While all competitive objectives were identified to be important in all business areas, in the elevator business area a specific focus with regards to safety, i.e. trapped people in elevators, could be observed. In mining equipment, a very high focus was observed on prevention, and in the IT hardware business area, key importance was stated with regards to security.

For the community studied, it can therefore be recommended to utilize a mixed approach of the sand cone model as well as the focus approach. As it is the key to especially improve speed/timeliness in all cases while not risking trade-offs on the other objectives, the sand cone model provides a solid approach that can be applied and has proven to be applicable before. Additionally, safety, security and prevention should be added and should be addressed based on the specific needs in each business area, i.e. by utilizing the focus approach. This is also summarized in **Figure 43**.

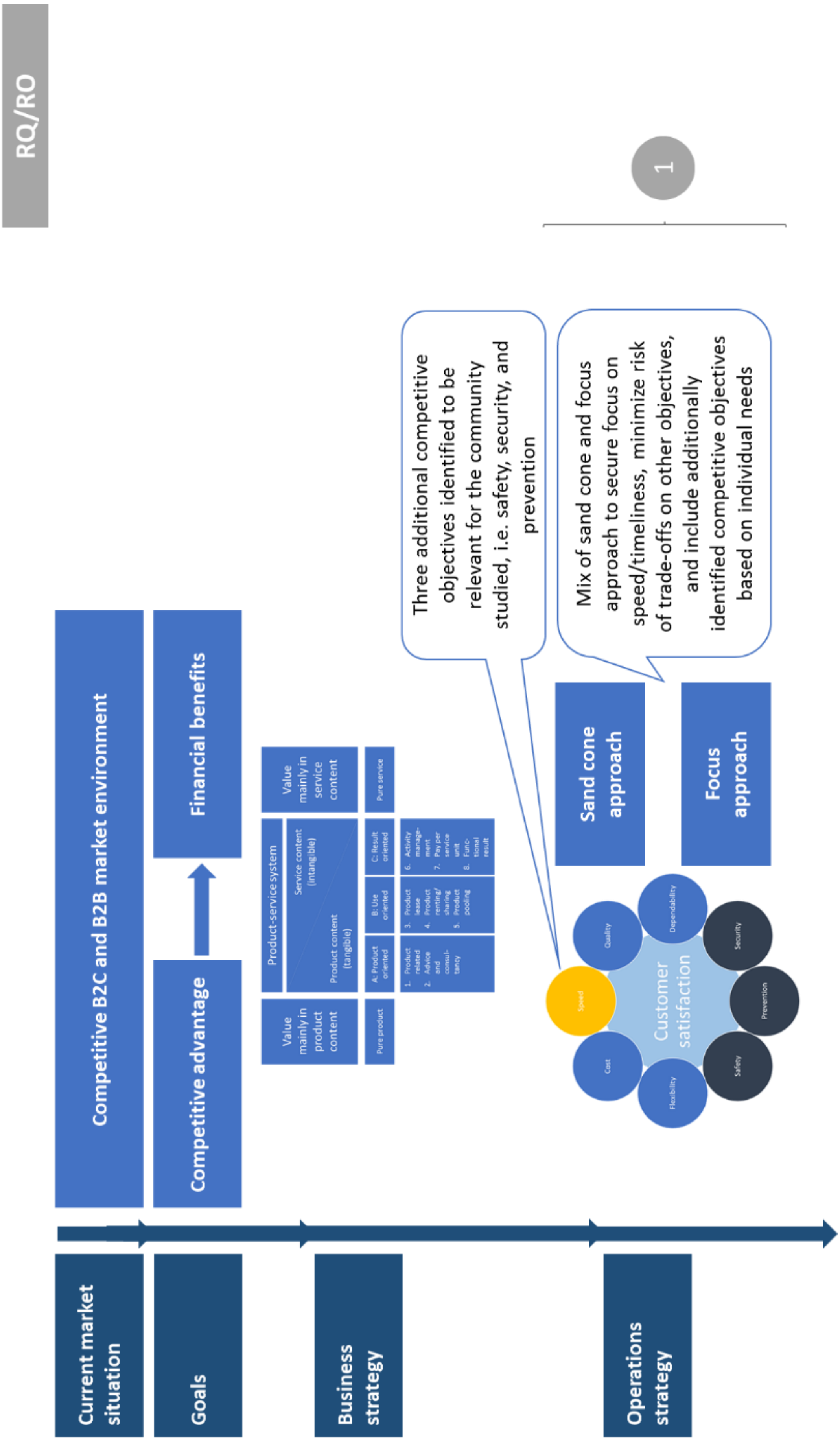


Figure 43: Extract of extended Figure 24, showing the contributions to RQ/RO 1

Whilst the results displayed in this chapter specifically deal with the first research question and research objective, the results will furthermore be utilized as part of the consensus construction (RQ/RO 4 in **Chapter 4.3.6**).

4.3.4 Perceived influence factors on service technicians' stationary equipment corrective maintenance response time

In general, it was observed throughout the case studies and especially the interviews and process observations that regardless of the business area, the corrective maintenance process, with slight variations in each business area and/or company, region, etc. depending on the circumstances and specifications, always could be categorized into the process steps suggested by Cohen et al (1997) in **Figure 18** (see **Chapter 2.3.3.1**). These process steps, which are undergone in every business area include the main process steps of a customer calling to initiate the process by demanding corrective maintenance, followed by remote diagnosis either through the service technician or a back office agent/technician, driving to and accessing the unit, on-site diagnosis, ordering and receiving parts, if necessary, and finally repairing the unit.

In each of the corrective maintenance process steps (based on Cohen et al, 1997), the case studies have furthermore shown a large amount of perceived factors that influence the service technicians with regards to the service response time. Some of these factors were mentioned in all business areas, some were only mentioned by one or a few expert(s) or specifically in a certain business areas. To derive with a consensus construction around the factors affecting service technicians with respect to stationary equipment corrective maintenance response time in the community studied, it is the intention of this chapter to analyse the factors in detail, to identify equivalents for the three cases, to display the data from the three cases in a combined display and to generate meaning around it. Furthermore, it is the intention to show the connection between the factors as well as the previously derived competitive objectives.

To structure the perceived factors, and as displayed in the respective chapters on factors in **Chapter 4.2** (**Chapter 4.2.3.4**, **Chapter 4.2.4.4**, and **Chapter 4.2.5.4**), a differentiation between direct and operational influences, strategic and indirect influences, as well as other and non-influenceable factors has been made. Thereby it was clearly observed, that the majority of factors identified could be clustered into the direct and operational influences, i.e. the different process steps. Overall, a total of 57 different factors have been identified and perceived to be relevant by the experts during the course of the three case studies conducted. **Table 22** displays an overview of all factors named in all three business areas as well as in which business area they were named to be relevant. As in the respective chapters previously, the factors are thereby clustered to show their relevance in the different process steps as well as with regards to the different levers, i.e. operational, strategic, and others.

Influence type	Process steps	Influence factors	Influence on BA		
			Elevator	Mining equipment	IT hardware
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information	x	x	x
		Offering remote help/service	x	x	x
		Experience/knowledge/know-how	x	x	x
		Pre-identification through operators/on-site technicians of customer		x	
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)	x	x	x
		Technicians located on-site (direct access/little travelling)	x	x	x
		Prioritization of jobs/dispatching/planning	x	x	x
		Routing/scheduling	x		x
		Availability of key boxes on-site	x		
		Availability of facility management/(security) personnel on-site	x		x
		Access to units in high security areas (safety/health tests, etc.)	x	x	x
		Visa requirements		x	
		Cars not equipped with navigation systems/GPS	x		x
		Language barriers and cultural differences		x	
	Diagnosis (on-site)	Availability of diagnostic tools	x	x	x
		Availability of diagnostic intelligence structures	x	x	x
		Too quick diagnosis and thus not identifying the entire issue	x		
		Availability of high quality spare parts catalogs/manuals	x	x	x
		Availability of electronic devices/support	x	x	x
		Information/barcodes/RFID/scanning functions on spare parts	x		x
		Information on customer/unit/other information	x	x	x
		Expert structures to identify issues/spare parts	x	x	x
		Experience/knowledge/know-how	x		x
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)	x	x	x
		Availability of car stock/site stock	x	x	x
		Availability of stock location network with quick deliveries	x	x	x
		Complexity of ordering process (electronical/paperless vs. manual)	x	x	x
		Ordering the right part(s)	x		x
		Availability of old parts and missing alternatives	x		
		Availability of third-party parts	x		
		Availability of custom made spare parts		x	
		Utilization of local purchasing options	x		
	Receiving	Availability of different delivery options to be flexible	x	x	x
		Pick up of spare parts at warehouse	x		x
		Delivery to pickpoints/PUDOs	x		x
		Delivery to service technicians' vans/cars/trucks	x		x
		Delivery to site	x	x	x
		Availability of express/emergency deliveries	x	x	x
	Repairing	Experience/knowledge/know-how	x	x	x
		Availability of the right (quality) tools	x	x	x
		First time fixes as main goal/repair plan	x	x	x
		Temporary/alternative solutions		x	x
		Terms/conditions/liabilities/service level agreements/contractual agreements	x	x	x
		Module based exchange of parts			x
		Communication and exchange of information possibilities	x	x	x
Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician	x	x	x
		Number of service technicians to secure proximity to units	x	x	x
		Training possibilities	x	x	x
		Fluctuation of service technicians/scarcity of qualified technicians	x	x	x
		Out-of-office times	x		x
		Top management attention for corrective maintenance/service oriented mindset within the company	x	x	x
		Keeping up to pace with market trends	x		x
		(Intrinsic) motivation of service technicians	x	x	x
Other influences	Non-influenceable circumstances	Traffic jams	x		x
		Weather conditions	x	x	x
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)	x	x	x
		Laws/regulations/customs	x	x	

Table 22: Overview of perceived factors affecting service technicians in corrective maintenance for stationary equipment in the three business areas observed

Based on this overview of perceived factors, it can be seen on the one hand that the majority of factors mentioned was stated to be relevant in all three business areas. Examples of factors that were mentioned in each case study, for instance, are intelligent questioning to retrieve information during remote diagnosis, travelling to the unit and the proximity to the unit, availability of diagnostic tools, the clarity of terms, conditions, liabilities, service level and contractual agreements, training possibilities for the technicians, top management attention for corrective maintenance and a service oriented mindset within the company, the need for first time fixes, and many more.

On the other hand, it can be seen that numerous factors were only mentioned in one or two of the three cases explored. This, however, does not necessarily imply that these factors are not relevant in the other business area(s).

A factor that was only mentioned to be relevant in mining equipment, for instance, was the pre-identification of an issue through the operator or on-site technicians of the customer during remote diagnosis. While this is particularly important in mining equipment, where a lot of technicians are always directly on-site, its relevance in elevator and IT hardware is just as important. In both of these industries, on-site personnel generally exists, e.g. janitors, technical facility supervisors, etc. By properly including this personnel in the corrective maintenance process of the equipment, these factors can be an influence in order to reduce response times and eventually equipment downtimes.

Another example are key boxes. While these were only mentioned to be relevant in the elevator industry, there are equivalents in mining equipment and IT hardware as well. In IT hardware, for instance, units can generally only be maintained when a certain code is entered. This might only be known to on-site personnel. Therefore, finding the technical supervisor or security personnel, who can grant access to a certain unit, may also be a factor in this industry. In mining equipment, access to a unit can also only be realized after having approached the relevant personnel with access rights.

A third example, where non-mentioning of a factor may not imply irrelevance is the factor of language barriers and cultural differences. These points were only mentioned in the mining equipment industry. Here, service technicians cover large areas, e.g. Southern Africa, with a lot of different cultures and languages, which again might affect response time due to uncertainties or longer discussions. While this was not mentioned in the other business areas, possibly mainly because the radiuses of operations of service technicians in these business areas are generally much smaller and very regional, and in most areas this is not an issue at all, language and cultural barriers can still exist in these business areas, e.g. in Switzerland or Belgium, where multiple different languages are spoken, or, for instance, when subcontractor companies from other countries are hired to support in this process. Furthermore, as mentioned by some experts in the elevator industry, sometimes experts need to be flown in into certain locations for specific issues. In these cases, language barriers can also create response time influences. Furthermore, on a different level, technical language may be an issue relevant to consider in this context in all three business areas, as it may not be understood by every person involved in the process, therefore potentially causing delays.

Also, module based exchange of parts, for instance, has only been mentioned in IT hardware. However, module based exchanges of parts or entire sections also occur in elevator and in mining equipment and therefore also provide relevance in these business areas. Routing and scheduling, which was only mentioned in the elevator and IT hardware industries, also is a very important factor in mining equipment, where specialized experts need to be planned for multiple jobs in large areas and regions, and the availability of old parts or third-party parts, which were both only mentioned in the elevator business area, are factors in IT hardware and mining equipment as well. In both of these industries, it was mentioned by the experts that not only own products are serviced, but also third-party equipment. Therefore, the availability of third-party equipment clearly is a factor in all three business areas. The same applies for old parts. As not only new or modern equipment is part of the companies' portfolios, the availability of parts for older units may have an impact on service response times as well.

Overall, for the community studied, it has shown that all of the 57 perceived factors identified throughout the three case studies are relevant and impact the service response time in corrective maintenance. Whilst some factors were only mentioned in a specific business area, or may be specifically relevant for a certain industry, equivalents and implications for the entire community studied could be observed through the analysis. It can therefore be stated, that in terms of the consensus construction to be created in **Chapter 4.3.6**, a total of 57 identified factors affecting service technicians' service response time in corrective maintenance for stationary equipment, which were identified in the different process steps as well as in direct/operational settings, indirect/strategic settings as well as in non-influenceable circumstances, are relevant in the community studied.

To further analyze the perceived influence factors, their relevance for the competitive objectives identified in this context is displayed. Therefore, an overview of all 57 factors and the according applicability and relevance to the eight competitive objectives, i.e. costs, speed, flexibility, safety, dependability, security, prevention, and quality, is displayed in **Table 23**. Again, this is displayed per process step as well as influence lever.

Influence type	Process steps	Influence factors	Influence on competitve objectives							
			Costs	Speed	Flexibility	Safety	Dependa-bility	Security	Prevention	Quality
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information	x	x	x		x		x	x
		Offering remote help/service	x	x	x	x	x		x	x
		Experience/knowledge/know-how	x	x	x	x	x		x	x
		Pre-identification through operators/on-site technicians of customer	x	x	x	x	x		x	x
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)	x	x	x	x	x			
		Technicians located on-site (direct access/little travelling)	x	x	x	x	x			
		Prioritization of jobs/dispatching/planning	x	x	x	x	x			
		Routing/scheduling	x	x	x		x			
		Availability of key boxes on-site	x	x	x		x	x		
		Availability of facility management/(security) personnel on-site	x	x	x		x	x		
		Access to units in high security areas (safety/health tests, etc.)	x	x	x		x	x		
		Visa requirements	x	x	x		x			
		Cars not equipped with navigation systems/GPS	x	x	x	x	x			
		Language barriers and cultural differences	x	x			x			
	Diagnosis (on-site)	Availability of diagnostic tools	x	x	x	x	x		x	x
		Availability of diagnostic intelligence structures	x	x	x	x	x		x	x
		Too quick diagnosis and thus not identifying the entire issue	x	x			x		x	x
		Availability of high quality spare parts catalogs/manuals	x	x	x		x			x
		Availability of electronic devices/support	x	x	x		x		x	x
		Information/barcodes/RFID/scanning functions on spare parts	x	x	x	x	x			x
		Information on customer/unit/other information	x	x	x	x	x		x	x
		Expert structures to identify issues/spare parts	x	x	x		x		x	x
		Experience/knowledge/know-how	x	x	x	x	x		x	x
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)	x	x	x		x			
		Availability of car stock/site stock	x	x	x	x	x			
		Availability of stock location network with quick deliveries	x	x	x		x			
		Complexity of ordering process (electronical/paperless vs. manual)	x	x	x		x			
		Ordering the right part(s)	x	x	x		x			x
		Availability of old parts and missing alternatives	x	x	x		x			x
		Availability of third-party parts	x	x	x		x			x
		Availability of custom made spare parts	x	x	x		x			x
		Utilization of local purchasing options	x	x	x		x			
	Receiving	Availability of different delivery options to be flexible	x	x	x	x	x			
		Pick up of spare parts at warehouse	x	x	x		x			
		Delivery to pickpoints/PUDOs	x	x	x		x			
		Delivery to service technicians' vans/cars/trucks	x	x	x		x			
		Delivery to site	x	x	x		x			
		Availability of express/emergency deliveries	x	x	x	x	x			
	Repairing	Experience/knowledge/know-how	x	x	x	x	x		x	x
		Availability of the right (quality) tools	x	x	x	x	x			x
		First time fixes as main goal/repair plan	x	x	x	x	x		x	x
		Temporary/alternative solutions	x	x	x	x	x		x	x
		Terms/conditions/liabilities/service level agreements/contractual agreements	x	x			x	x		
		Module based exchange of parts	x	x	x	x	x		x	x
		Communication and exchange of information possibilities	x	x	x	x	x		x	x
Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician	x	x	x	x	x			x
		Number of service technicians to secure proximity to units	x	x	x	x	x			x
		Training possibilities	x	x	x	x	x		x	x
		Fluctuation of service technicians/scarcity of qualified technicians	x	x	x	x	x	x		x
		Out-of-office times	x	x	x	x	x			
		Top management attention for corrective maintenance/service oriented mindset within the company	x	x	x	x	x			x
		Keeping up to pace with market trends	x	x	x		x		x	x
		(Intrinsic) motivation of service technicians	x	x	x	x	x		x	x
Other influences	Non-influenceable circumstances	Traffic jams	x	x	x	x	x			
		Weather conditions	x	x	x	x	x			
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)	x	x	x	x	x			
		Laws/regulations/customs	x	x	x	x	x			

Table 23: Overview of perceived factors affecting service technicians and the competitive objectives in corrective maintenance for stationary equipment in the three business areas observed

Specifically, this analysis shows that, as expected, all factors have an influence on speed/timeliness. Furthermore, it can be seen that dependability, flexibility and costs are affected by a comparably large amount of factors. Quality, safety and prevention are also affected by a comparably large number of factors, however, fewer than the objectives mentioned previously. The least affected objective by the factors is security. Furthermore, it can be observed that all factors may have an effect on multiple objectives simultaneously. The minimum observed is three objectives influenced by a factor, the maximum is seven objectives influenced by a factor.

An example for a factor that influences a comparably lower number of objectives on the one hand thereby, for instance, is the approval process for spare parts ordering. This factor obviously affects speed/timeliness, but also the dependability and flexibility of the service technician in the process. Overall, by delaying the corrective maintenance process, it can also have an influence on costs. Safety, security, prevention and quality are not affected by this factor.

On the other hand side, a factor that influences a comparably large number of objectives, for instance, is the availability of diagnostic tools. This factor may affect all competitive objectives except safety. Diagnostic tools help the technicians in order to quickly diagnose an issue (speed/timeliness), they allow dependability and flexibility in the process, and thereby reduce costs. Also they affect the safety of the service technician, as they do not have to search for the issues manually, they may affect prevention through detecting further issues that may have caused additional issues at a later stage and they allow for high quality maintenance, as the right counter-measures can be initialized based on the utilization of these tools.

As seen in the previous chapter (**Chapter 4.3.3**), for this research and the community studied, when utilizing a mix of the sand cone model approach (Ferdows et al, 1990; Slack et al, 2014) as well as the focus approach (Slack et al, 2014), this means that especially the factors that affect speed/timeliness, as well as quality and dependability as the preliminary steps in order to avoid trade-off effects, need to be considered. To add onto that, a focus on relevant factors that have specific influence on individual company or business area needs can then be added in order to achieve the final target of customer satisfaction and thus high competitiveness. This analysis therefore adds on to the baseline created by the 57 factors, and is needed in order to prioritize the factors, further reduce the data, and to generate a consensus construction for applicability in the community studied. This will be displayed in **Chapter 4.3.6**.

The findings and contributions of this chapter are displayed in **Figure 44**.

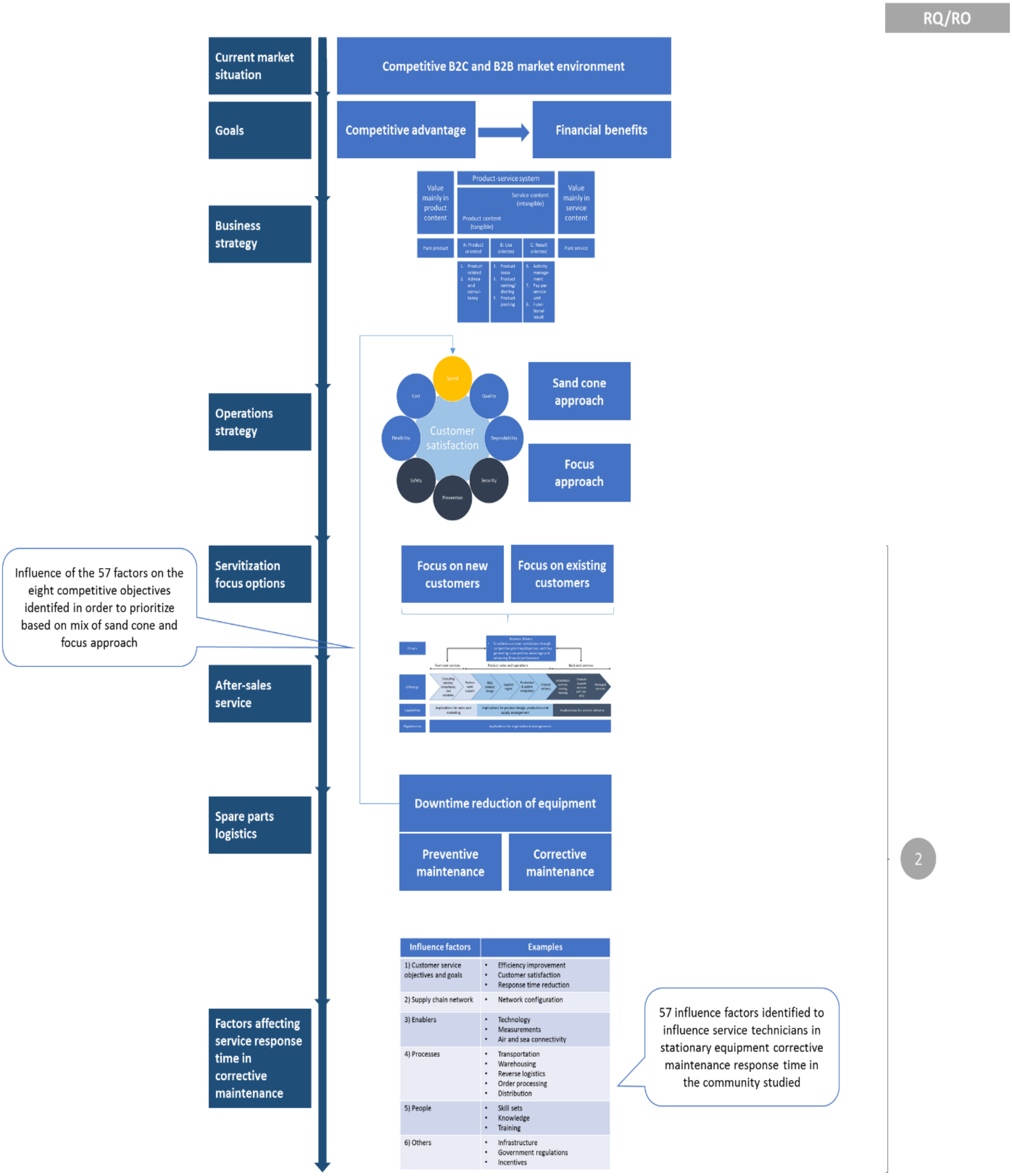


Figure 44: Extract of extended Figure 24, showing the contributions to RQ/RO 2

Whilst the results displayed in this chapter specifically deal with the second research question and research objective, the results will furthermore be utilized as part of the consensus construction (RQ/RO 4 in **Chapter 4.3.6**).

4.3.5 Perceived optimization opportunities in service technicians' stationary equipment corrective maintenance response time

In order to appropriately react to the 57 perceived identified factors that influence the service technicians with regards to response time in corrective maintenance, within the empirical case study research a total of 87 different perceived possible improvement opportunities was identified (see **Table 24**). The listed perceived improvement opportunities were mentioned by the interviewees or discovered through the process observations and data analyses during the three case studies.

Solution Number	Solutions/ improvement possibilities
1	Smart questioning manuals/instructions, e.g. perfect call descriptions
2	Service centre trainings
3	Back-up equipment of certain units/parts to support in error identification remotely
4	Increase remote service/assistance focus
5	Install experienced technicians in remote positions
6	Sensors/preventive software/systems with error possibility notifications
7	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.
8	Visit new customers/units to retrieve all necessary information
9	Service centres in close proximity to major service markets
10	Geo-tracking
11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.
12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device
13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site
14	Two passports per service technician, if necessary
15	Navigation system/GPS in every car
16	Language/intercultural trainings
17	High quality diagnostic tools
18	Third-party equipment diagnostic tools
19	Image recognition software for mobile devices (such as Google glasses)
20	Augmented reality applications, that show information on parts/units
21	RFID/Scanning functions on mobile devices
22	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.
23	Access units remotely through clouds
24	Online/electronical spare parts catalogs/manuals available on mobile devices
25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices
26	3D-drawings/explosion drawings were necessary in catalog on mobile devices
27	Multiple pictures from various angles per spare part in catalog on mobile devices
28	Regular updates of catalog on mobile devices
29	Mobile device for every service technician
30	Strong IT-/ERP-support
31	Unique parts numbers that match with information in catalog on mobile devices
32	Additional information on spare parts that matches with information in catalog on mobile devices
33	RFID/Scanning functions on spare parts
34	Bill of matierial per unit
35	Easy exchange of information and pictures in chat functions on mobile devices
36	Different technicians/support levels for different issues
37	Specialization trainings

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38	Regular technical trainings (knowledge building and refreshments)
39	Customer management/orientation trainings
40	Paperless approvals through mobile devices
41	Install fast track ordering process in urgent cases, where usually, due to the price of the spare parts, three offers would be needed
42	Clear approval processes/structures implemented
43	Automatic car stock replenishment through mobile device bookings/statistics
44	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates
45	Automatic stock location replenishment through software
46	Mobile device should show nearest available stock location for each part
47	In emergencies, make use of parts produced for new installations (manufacturing centres)
48	Web shop for direct ordering via mobile device
49	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device
50	Paperless orders/bookings through RFID/scanning functions on mobile device
51	3D-printing
52	Clear identification/diagnosis processes
53	Supplier relationship management for a network with quick delivery times
54	Allowing local purchases with easy processes in situations, where other options are not as good
55	Create a flexible delivery concept with multiple options for the technicians/customers to pick from
56	Possibility to pick up parts at warehouse, if necessary, and pre-notification through mobile devices
57	Possibility to have parts delivered to pick points/PUDOs through mobile devices
58	Reliable forwarders
59	Forwarders with extensive network of pickpoints/PUDOs
60	Possibility to have parts delivered into cars/vans/trucks through mobile devices
61	Possibility to have parts delivered to site through mobile devices
62	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices
63	Repair kits with standard tools
64	Repair kits with standard parts for certain issues
65	High quality and light tools
66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office
67	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device
68	Agreements should be dealt with by back office and not affect service technician
69	Design platform based units to reduce the number of parts
70	Design module based solutions
71	Utilize/hire service technicians from other business areas
72	Monitor service technicians performance (where possible) in order to point out improvement opportunities
73	Mirror training needs with actual trainings received regularly
74	Administrative trainings
75	Softskill trainings
76	Incentivize technicians
77	Beware of technicians' needs
78	Incorporate technicians' knowledge
79	Motivate technicians through trainings, etc.
80	Safety focus, e.g. through dead-man-function
81	Install emergency service for out-of-office times according to service level agreements
82	Install globally used KPI to measure service response time
83	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher networking capital)
84	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings
85	Communicate new products/production stops to after-sales service department structured and well in advance
86	Make use of and monitor customer feedback
87	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly

Table 24: Overview of perceived possible solutions identified to improve service technicians' performance with respect to the identified factors in corrective maintenance response time for stationary equipment

Here, just like for the perceived factors identified, also for the perceived improvement opportunities it has to be stated that the applicability was analyzed for the entire community studied. This means, for instance, that factors, which were mentioned only in one or two of the business areas, have been analyzed for applicability in the other business areas as well. An example in this case is back-up equipment of certain units and parts to support in error identification remotely. Whilst this was only mentioned as an opportunity in IT hardware, it would boost improvement opportunities in elevator and mining equipment as well. Having exemplary units of especially vulnerable parts available for the remote service assistants to look at during remote analysis and problem solving, for instance, would certainly generate opportunities to improve response times. Other examples are, for instance the availability of multiple pictures from various angles per spare part within the mobile device catalogs, the availability of mobile devices for every service technician, and to design platform based units to reduce the number of spare parts. These were mentioned in the elevator and IT hardware industry, but would also be beneficial for mining equipment.

To make sure that all identified factors can potentially be improved, the solutions were then matched with the factors, resulting in an overview table where for every factor at least one possible solution is shown (please refer to **Table 25**). Some solutions, of course, can affect multiple factors and hence are listed multiple times, resulting in a total of 133 solutions for the 57 factors. On average, 2.33 solutions/improvement opportunities per factor, with the minimum being one solution and the maximum being eight solutions per factor, were identified thereby.

To further reduce the data within the large amount of solutions, three particular areas of improvement were clustered/coded during the analysis and thereby made visible. These three categories largely influence the factors on technicians in stationary equipment corrective maintenance response time and namely are technical assistance, enabling the service technician, as well as back office support.

Technical assistance, in this case, is anything that is related to IT, tools and gadgets, etc., which support the technician in the corrective maintenance process. Enabling the service technician includes anything related to the personal development and functioning of the service technician in the corrective maintenance process, i.e. knowledge, experience or know-how, and back office support deals with any support process coming from the purchasing department, logistics, product engineering, the service centre or any other back office support function. All 87 solution could be categorized into one of the three improvement areas. Please refer to **Table 25** for an overview.

Influence type	Process steps	Influence factors	Solu-tion	Solutions/improvement possibilities	Improvement area
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information	1	Smart questioning manuals/instructions, e.g. perfect call descriptions	Back office support
			2	Service centre trainings	Enabling technician
			3	Back-up equipment of certain units/parts to support in error identification remotely	Technical assistance
		Offering remote help/service	1	Smart questioning manuals/instructions, e.g. perfect call descriptions	Back office support
			4	Increase remote service/assistance focus	Back office support
			3	Back-up equipment of certain units/parts to support in error identification remotely	Technical assistance
		Experience/knowledge/know-how	5	Install experienced technicians in remote positions	Enabling technician
			2	Service centre trainings	Enabling technician
		Pre-identification through operators/on-site technicians of customer	1	Smart questioning manuals/instructions, e.g. perfect call descriptions	Back office support
			6	Sensors/preventive software/systems with error possibility notifications	Technical assistance
			3	Back-up equipment of certain units/parts to support in error identification remotely	Technical assistance
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)	47	In emergencies, make use of parts produced for new installations (manufacturing centres)	Back office support
			8	Visit new customers/units to retrieve all necessary information	Back office support
			9	Service centres in close proximity to major service markets	Back office support
		Technicians located on-site (direct access/little travelling)	7	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.	Back office support
		Prioritization of jobs/dispatching/planning	10	Geo-tracking	Technical assistance
			11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	Technical assistance
		Routing/scheduling	10	Geo-tracking	Technical assistance
			11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	Technical assistance
		Availability of key boxes on-site	12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance
		Availability of facility management/(security) personnel on-site	12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance
		Access to units in high security areas (safety/health tests, etc.)	13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	Back office support
		Visa requirements	13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	Back office support
			14	Two passports per service technician, if necessary	Enabling technician
		Cars not equipped with navigation systems/GPS	15	Navigation system/GPS in every car	Technical assistance
		Language barriers and cultural differences	16	Language/intercultural trainings	Enabling technician
	Diagnosis (on-site)	Availability of diagnostic tools	17	High quality diagnostic tools	Technical assistance
			18	Third-party equipment diagnostic tools	Technical assistance
			19	Image recognition software for mobile devices (such as Google glasses)	Technical assistance
			20	Augmented reality applications, that show information on parts/units	Technical assistance
			21	RFID/Scanning functions on mobile devices	Technical assistance
			22	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.	Technical assistance
		Availability of diagnostic intelligence structures	23	Access units remotely through clouds	Technical assistance
			6	Sensors/preventive software/systems with error possibility notifications	Technical assistance
		Too quick diagnosis and thus not identifying the entire issue	24	Online/electronical spare parts catalogs/manuals available on mobile devices	Technical assistance
			25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices	Technical assistance
			26	3D-drawings/explosion drawings were necessary in catalog on mobile devices	Technical assistance
			27	Multiple pictures from various angles per spare part in catalog on mobile devices	Technical assistance
			28	Regular updates of catalog on mobile devices	Technical assistance
		Availability of high quality spare parts catalogs/manuals	24	Online/electronical spare parts catalogs/manuals available on mobile devices	Technical assistance
			25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices	Technical assistance
			26	3D-drawings/explosion drawings were necessary in catalog on mobile devices	Technical assistance
			27	Multiple pictures from various angles per spare part in catalog on mobile devices	Technical assistance
			28	Regular updates of catalog on mobile devices	Technical assistance
		Availability of electronic devices/support	29	Mobile device for every service technician	Technical assistance
			30	Strong IT-/ERP-support	Technical assistance
		Information/barcodes/RFID/scanning functions on spare parts	31	Unique parts numbers that match with information in catalog on mobile devices	Technical assistance
			32	Additional information on spare parts that matches with information in catalog on mobile devices	Technical assistance
			33	RFID/Scanning functions on spare parts	Technical assistance
		Information on customer/unit/other information	34	Bill of matierial per unit	Technical assistance
			12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance
		Expert structures to identify issues/spare parts	35	Easy exchange of information and pictures in chat functions on mobile devices	Technical assistance
			36	Different technicians/support levels for different issues	Enabling technician
		Experience/knowledge/know-how	37	Specialization trainings	Enabling technician
			16	Language/intercultural trainings	Enabling technician
			38	Regular technical trainings (knowledge building and refreshments)	Enabling technician
			39	Customer management/orientation trainings	Enabling technician

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	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)	40	Paperless approvals through mobile devices	Technical assistance
			41	Install fast track ordering process in urgent cases, where usually, due to the price of the spare parts, three offers would be needed	Back office support
			42	Clear approval processes/structures implemented	Back office support
		Availability of car stock/site stock	43	Automatic car stock replenishment through mobile device bookings/statistics	Technical assistance
			44	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates	Back office support
		Availability of stock location network with quick deliveries	45	Automatic stock location replenishment through software	Technical assistance
			46	Mobile device should show nearest available stock location for each part	Technical assistance
			47	In emergencies, make use of parts produced for new installations (manufacturing centres)	Back office support
		Complexity of ordering process (electronical/paperless vs. manual)	48	Web shop for direct ordering via mobile device	Technical assistance
			49	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device	Technical assistance
			50	Paperless orders/bookings through RFID/scanning functions on mobile device	Technical assistance
		Ordering the right part(s)	51	3D-printing	Technical assistance
			52	Clear identification/diagnosis processes	Back office support
		Availability of old parts and missing alternatives	51	3D-printing	Technical assistance
			53	Supplier relationship management for a network with quick delivery times	Back office support
		Availability of third-party parts	51	3D-printing	Technical assistance
			53	Supplier relationship management for a network with quick delivery times	Back office support
		Availability of custom made spare parts	51	3D-printing	Technical assistance
			53	Supplier relationship management for a network with quick delivery times	Back office support
		Utilization of local purchasing options	54	Allowing local purchases with easy processes in situations, where other options are not as good	Back office support
	Receiving	Availability of different delivery options to be flexible	55	Create a flexible delivery concept with multiple options for the technicians/customers to pick from	Back office support
		Pick up of spare parts at warehouse	56	Possibility to pick up parts at warehouse, if necessary, and pre-notification through mobile devices	Technical assistance
		Delivery to pickpoints/PUDOs	57	Possibility to have parts delivered to pick points/PUDOs through mobile devices	Technical assistance
			58	Reliable forwarders	Back office support
			59	Forwarders with extensive network of pickpoints/PUDOs	Back office support
		Delivery to service technicians' vans/cars/trucks	60	Possibility to have parts delivered into cars/vans/trucks through mobile devices	Technical assistance
			58	Reliable forwarders	Back office support
		Delivery to site	61	Possibility to have parts delivered to site through mobile devices	Technical assistance
			58	Reliable forwarders	Back office support
		Availability of express/emergency deliveries	62	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices	Technical assistance
	Repairing	Experience/knowledge/know-how	37	Specialization trainings	Enabling technician
			16	Language/intercultural trainings	Enabling technician
			38	Regular technical trainings (knowledge building and refreshments)	Enabling technician
			39	Customer management/orientation trainings	Enabling technician
		Availability of the right (quality) tools	63	Repair kits with standard tools	Technical assistance
			64	Repair kits with standard parts for certain issues	Technical assistance
			65	High quality and light tools	Technical assistance
		First time fixes as main goal/repair plan	66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office	Back office support
			23	Access units remotely through clouds	Technical assistance
		Temporary/alternative solutions	12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance
			66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office	Back office support
		Terms/conditions/liabilities/service level agreements/contractual agreements	67	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device	Technical assistance
			68	Agreements should be dealt with by back office and not affect service technician	Back office support
		Module based exchange of parts	69	Design platform based units to reduce the number of parts	Back office support
			70	Design module based solutions	Back office support
		Communication and exchange of information possibilities	35	Easy exchange of information and pictures in chat functions on mobile devices	Technical assistance

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Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician	37	Specialization trainings	Enabling technician
		Number of service technicians to secure proximity to units	36	Different technicians/support levels for different issues	Back office support
			71	Utilize/hire service technicians from other business areas	Back office support
		Training possibilities	72	Monitor service technicians performance (where possible) in order to point out improvement opportunities	Enabling technician
			73	Mirror training needs with actual trainings received regularly	Enabling technician
			37	Specialization trainings	Enabling technician
			38	Regular technical trainings (knowledge building and refreshments)	Enabling technician
			74	Administrative trainings	Enabling technician
			75	Softskill trainings	Enabling technician
			16	Language/intercultural trainings	Enabling technician
			39	Customer management/orientation trainings	Enabling technician
		Fluctuation of service technicians/scarcity of qualified technicians	76	Incentivize technicians	Enabling technician
			77	Beware of technicians' needs	Enabling technician
			78	Incorporate technicians' knowledge	Enabling technician
			79	Motivate technicians through trainings, etc.	Enabling technician
			80	Safety focus, e.g. through dead-man-function	Enabling technician
			71	Utilize/hire service technicians from other business areas	Back office support
		Out-of-office times	81	Install emergency service for out-of-office times according to service level agreements	Back office support
		Top management attention for corrective maintenance/service oriented mindset within the company	82	Install globally used KPI to measure service response time	Back office support
			83	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher networking capital)	Back office support
		Keeping up to pace with market trends	84	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings	Enabling technician
			85	Communicate new products/production stops to after-sales service department structured and well in advance	Back office support
			86	Make use of and monitor customer feedback	Back office support
			87	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly	Back office support
		(Intrinsic) motivation of service technicians	72	Monitor service technicians performance (where possible) in order to point out improvement opportunities	Enabling technician
			76	Incentivize technicians	Enabling technician
			77	Beware of technicians' needs	Enabling technician
			78	Incorporate technicians' knowledge	Enabling technician
			79	Motivate technicians through trainings, etc.	Enabling technician
			80	Safety focus, e.g. through dead-man-function	Enabling technician
Other influences	Non-influenceable circumstances	Traffic jams	Not (or only hardly) influenceable: Should be covered through improvements that can be influenced, e.g. routing, proximity to units and navigation systems/GPS to avoid traffic jams, driving long distances or in heavy terrain, etc.		
		Weather conditions			
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)			
		Laws/regulations/customs			

Table 25: Overview of improvement opportunities with respect to factors influencing service technicians in corrective maintenance response time for stationary equipment

Factors that may have an effect on service technicians in corrective maintenance for stationary equipment with respect to response time, can be influenced by solutions coming from at least one of these categories, as stated before. Looking at the factor of service cars not being equipped with navigation systems/GPS, for instance, which is a direct/operational influence on the technician in the process step of driving/accessing the unit, the solely stated solution in the empirical case study research was to equip all service vehicles with navigation systems or GPS. This improvement opportunity clearly is a technical assistance gadget, which could positively affect the service technician with regards to response time in corrective maintenance. Improvement solutions, which would impact the technician him-/herself (enabling technician) or would be part of the back office support were not mentioned by the experts to be feasible.

When looking at the factor of intelligent questioning to retrieve information in the remote diagnosis process step, however, three possible solutions resulted from the case study research.

Here, if back-up equipment of certain units or parts is available to the technician handling the remote service, thus giving him/her the opportunity to look at the unit/part while conducting the service remotely, this would possibly have a positive effect on the response time in corrective maintenance. This solution can be categorized as technical assistance, as it improves the process based on a technical solution. Furthermore, the process could be improved by creating manuals/instructions, how to react in certain situations and which questions to ask in order to retrieve certain information. As the technician or person, who handles the remote service is not the service technician, who benefits from this information, this solution is clustered as back office support improvement. A third possibility is to train the service technicians in the field in service centre trainings, thus giving them the knowledge to retrieve information from the customer through smart questioning before accessing a site themselves, e.g. by calling in advance and thus increasing the chance to fix the issue quicker. This training is categorized as an enabler for the technician to improve his/her own performance with regards to response times in corrective maintenance.

Whilst in this case, each of the three potential improvements were categorized to influence the technician in the corrective maintenance process in a different way, i.e. through technical support, through back office support or through enhancing the technicians' own skills, for other factors, different combinations of solutions are true. For the factor of having a high quality spare parts catalog/manual available for on-site diagnosis, for instance, five potential improvements were generated through the empirical research. All of those solutions are technical advancements, which could improve the process and thus the service technicians' response time in corrective maintenance. These improvements include having an online/electronical spare parts catalogs/manuals available on mobile devices, multiple pictures from various angles per spare part in the catalogs/manuals, regular updates of the catalogs/manuals, etc.

The availability of old parts and missing alternatives in the process step of ordering can be reacted to by two potential solutions, for example, which are a combination of technical assistance, i.e. 3D-printing, as well as back office support, i.e. installing a supplier relationship network with quick delivery times for those parts.

Just like for all of the operational/direct influences on the service technician in this process, also for the strategic influences, solutions were identified through the case studies. The same principles and categorizations apply. For the other influences, i.e. the non-influenceable/hardly influenceable circumstances, which may also have an effect on the service technicians in the process, but cannot or cannot easily be influenced, no solutions were identified. Much rather, the very little that can be done for these factors, e.g. weather conditions, traffic jams, laws and regulations, etc. should be covered as much as possible by improving the factors that can be influenced. When equipping all cars with navigation systems or GPS, improving the routing of service technicians or generating closer proximities to the units, for example, traffic jams can still not be influenced. They may, however, be avoided more.

The different combinations/variations of solutions are displayed in detail in **Table 25** for every factor. Obviously, in this context it has to be noted that the three improvement areas may also overlap to certain degrees depending on the solutions generated through the research. Whenever a categorization was not entirely obvious, the influence area that was more affected was chosen.

This analysis, just like for the perceived influence factors, aims at generating an overview and baseline, which is needed in order to prioritize the large amount of perceived solutions, further reduce the data, and to generate a consensus construction for applicability in the community studied. This will be displayed in **Chapter 4.3.6**.

The findings and contributions of this chapter are displayed and summarized in **Figure 45**.

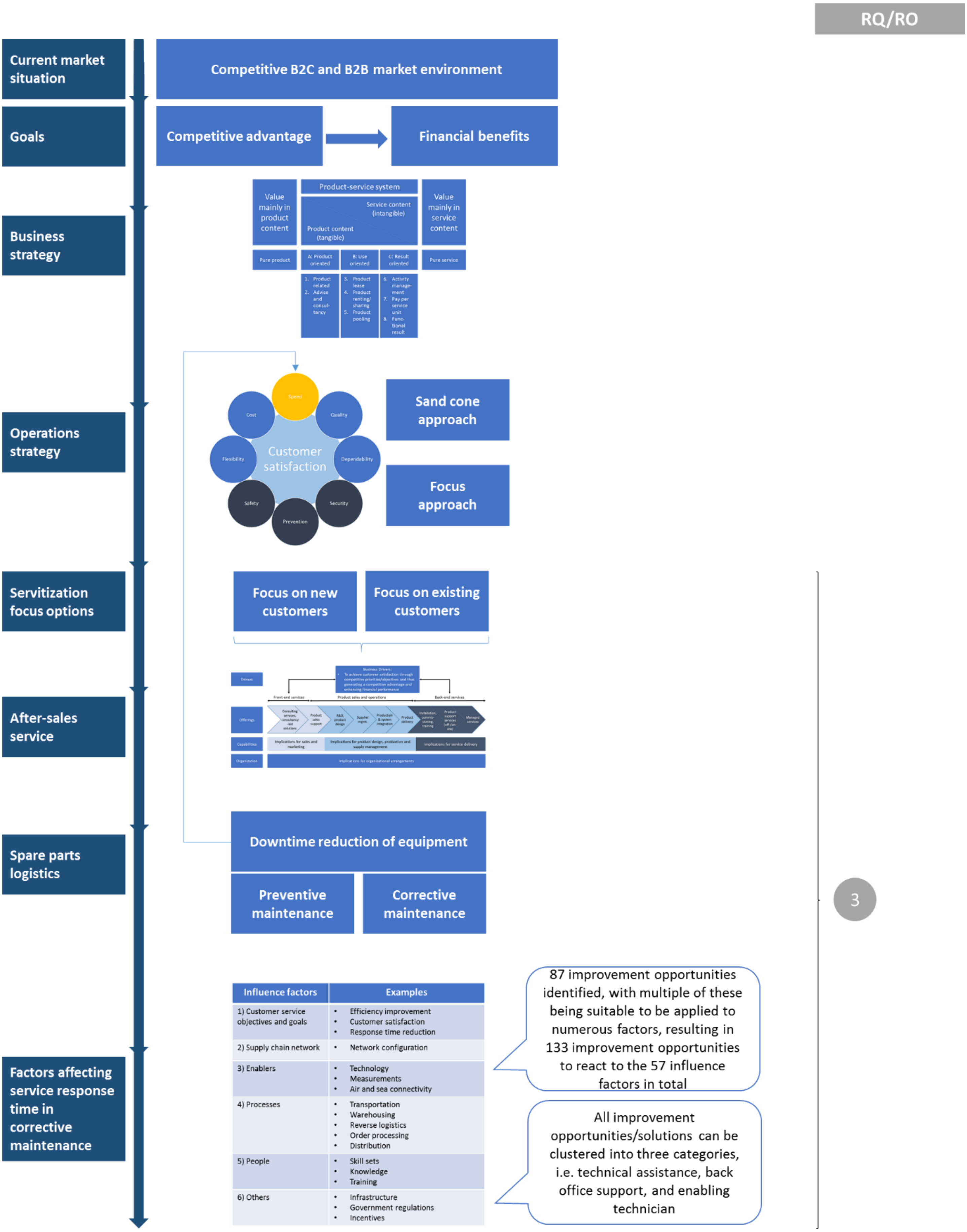

Figure 45: Extract of extended Figure 24, showing the contributions to RQ/RO 3

Whilst the results displayed in this chapter specifically deal with the third research question and research objective, the results will furthermore be utilized as part of the consensus construction (RQ/RO 4 in **Chapter 4.3.6**).

4.3.6 Consensus construction development for applicability in the community studied

4.3.6.1 Introduction

By having identified generally applicable competitive objectives for the community studied with respect to corrective maintenance as well as a total of 57 perceived influence factors on the technicians in this process and a total of 87 perceived different solutions (133, if including applicability to multiple factors) to potentially optimize the influence factors throughout the empirical research, a solid baseline for a consensus construction has been created.

The results have shown that despite the different products and circumstances in each respective business area or company within a business area in the community studied, the corrective maintenance process for stationary equipment is majorly similar and includes the same process steps generally in the community studied. Furthermore, an applicability of all eight competitive objectives to the context has been provided. The research has also shown that the baseline of identified perceived factors as well as improvement opportunities is applicable for the entire community involved in this research. Even though some influence factors on the service technicians in the corrective maintenance process for stationary equipment as well as some solutions may be especially useful for a certain business area or company, and have only been mentioned by experts from these business areas, the thorough analysis provided in the previous chapters shows full applicability.

The results from the three case studies can therefore be used to generate a consensus construction for the community studied that evaluates how factors affecting service technicians' performance in terms of service response time in corrective maintenance for stationary equipment can be prioritized and related to choices for improvements. The following chapters therefore further reduce the data generated, and prioritize both the influence factors as well as improvement opportunities in a structured way, before the results are merged to generate action recommendations.

4.3.6.2 Prioritization of influence factors

Based on the data derived from the three case studies conducted, in a first step, the analyses showed that direct/operational factors are perceived to be the highest influence source on the corrective maintenance response time. The operational/direct factors thereby are the factors that are present during the actual corrective maintenance process, i.e. diagnosis, driving to and accessing the unit, ordering, receiving and repairing, as described before. Strategic factors were also seen as important throughout the case study analyses, but less important than operational factors. Non-influenceable circumstances have been perceived to be of the least importance in all three cases included in the community studied. An overview is provided in **Table 26**.

Factor type	Importance (E)	Importance (M)	Importance (I)	Overall
Operational factors	very high	very high	very high	very high
Strategic factors	high	high	high	high
Non-influenceable circumstances	low	low	low	low

Table 26: Perceived importance of factors in the process

In order to build on these perceptions, in a second step, the process steps that deal with the operational factors have been analyzed in more depth with respect to corrective maintenance response time. Therefore, the best and worst cases in terms of response time have been analyzed during the empirical research (see **Table 27**).

	Process steps	Best case	Average case	Worst case
Operational/direct factors	Diagnosis (remotely)	5-15 min	10-30 min	several hours
	Driving to/accessing the unit	not needed (if needed: few minutes)	10-30 min	several days
	Diagnosis (on-site)	not needed (if needed: few minutes)	30 min	several days
	Ordering	not needed (if needed: few minutes)	30 min	several days
	Receiving	not needed (if needed: same day)	overnight	several weeks
	Repairing	5-15 min	30 min	several days
	Total	**10-30 min (in cases where only remote diagnosis and repairing are necessary)**	**1.5-2.5 h**	**several days-several weeks**

Table 27: Response time averages in corrective maintenance for stationary equipment in the community studied

The data shows that on average a corrective maintenance process for stationary equipment takes the service technicians around 1.5 to 2.5 hours. As soon as the customer calls, generally in normal/average cases, around ten to 30 minutes are needed for remote diagnosis. This includes information gathering, asking questions and potentially fixing the issue without needing to dispatch a technician to site. Even in the best case scenarios, five to 15 minutes are generally needed for this process step. In worst case scenarios, remote diagnosis can take multiple hours, e.g. in order to analyze data or internally identify the issue.

Driving to and accessing the site then usually on average takes around ten to 30 minutes, depending where the service technician is located. This is also true in mining equipment corrective maintenance, where distances are much greater than in other business areas. Here, the quick average response times are possible, when service technicians are located on-site. In cases, where the next technician is further away and needs to travel, however, usually technicians from the customer, who are generally present in mining equipment settings, are on-site right away and supported through remote assistance until the service technicians arrive. In the cases, where long distances have to be travelled, generally multiple hours (elevator and IT hardware) or days (mining equipment) can elapse before a service technician arrives.

The average on-site diagnosis process step takes around 30 minutes. This includes identifying the issue as well as possibly the part(s) to be exchanged. In bad case scenarios, where it is hard to identify the issue or multiple issues cause a disruption simultaneously, this process step can take multiple hours and even days as well. In cases, where remote diagnosis was sufficient, on-site diagnosis can be fully eliminated in the best cases.

Ordering and receiving on average can be handled quickly. A standard ordering process, even in cases where approval processes have to be complied with, on average take around 30 minutes. For every part that is not on stock, generally overnight delivery processes can be utilized to receive the needed parts. In worst case scenarios, ordering and receiving may, however, take several days or even weeks, for example when parts have to be custom made or are generally unavailable. In optimal cases, however, the service technician has the needed parts in the car stock and does not need to order and wait for reception at all.

The process step of reparation usually takes around another 30 minutes on average. This includes changing the part and checking, if the unit can go back into operation again. In more complicated cases, where issues have been identified wrongly or not fully, repair processes may take multiple days. In best case scenarios, where the solution and issue is obvious and where the parts to be exchanged are easily accessible, repairs can be conducted within five to 15 minutes.

Overall, the very worst cases of corrective maintenance for stationary equipment, where parts have to be custom made, are hard to source, where service technicians have to travel long distances, delivery modes are insufficient or the issue of a broken down unit cannot be identified right away, etc. can take several days and even weeks in total.

The very best cases in corrective maintenance for stationary equipment, however, where quick remote diagnosis is possible and where the customers are capable of quickly fixing the issues themselves, e.g. through machine restarts or module exchanges of broken down parts or consumables such as cartridges in IT hardware, can be handled within ten to 30 minutes. In these cases, driving to and accessing the units, on-site diagnosis, ordering and receiving become dispensable. Identifying the issue quickly and remotely and enabling the customers to solve the issues themselves quickly should therefore be the optimum target setting to be achieved for all corrective maintenance processes for stationary equipment in the community studied. If a service technician is required, however, also driving to and accessing the unit, on-site diagnosis, ordering, receiving and repairing can be optimized to a minimum.

After having identified the relevance of operational/direct factors in comparison to strategic/indirect factors and other factors/non-influenceable circumstances, as well as looking in detail on which process step in the operational corrective maintenance process is perceived to be the most relevant in terms of optimizing the entire process, in a third and final step, a prioritization of the actual influence factors is included. Therefore, the applicability and the relevance for the competitive objectives have been utilized.

As stated previously and as seen in **Chapter 4.3.3**, for the community studied in this research, a mix between the sand cone model approach and the focus approach is applied. As especially speed/timeliness is the key competitive objective in this context, obviously the factors that affect speed/timeliness should be prioritized first. As already stated, due to the nature of the research conducted, where specifically factors were tried to be identified that influence speed/timeliness, i.e. response time, all identified factors affect speed/timeliness and a prioritization is not possible. However, as the pre-conditions to generate a competitive advantage through speed/timeliness without risking trade-off effects state to focus on quality and dependability first (see **Figure 11** based on Ferdows et al, 1990 and Slack et al, 2014), factors that affect these competitive advantages are prioritized over other objectives as well.

The highest priority of factors to focus on therefore essentially is given to the factors that have an influence on quality, dependability and speed. When a factor has an influence on all these three factors, it can be utilized to generate the improvements needed in all three regards in a step-wise approach to minimize the risk of trade-offs. The next highest priority is given to factors that affect speed and quality, as quality is the first objective to be achieved based on the sand cone model approach. The third priority is given to factors that affect speed as well as dependability accordingly. To further include the focus approach, as suggested by Slack et al (2014), based on individual needs of the company or business area utilizing this construct, factors that in addition to speed, quality and/or dependability also affect a specific other competitive objective, should again increase the prioritization of a factor. If for instance, a company is highly focused on security, for example, and a prioritization between factors has to be made, the ones that focus on security in addition to the prioritizations made with regards to speed, quality and dependability should receive higher prioritization than factors without effects on security. This can be extended furthermore. If a company or business area is highly focussed on its flexibility and on prevention, but does not have specific needs in security, in addition to speed, quality and dependability, factors that affect these two objectives should be prioritized in order to achieve the highest individual benefit from the construct.

The baseline for the consensus construction to prioritize factors to focus on in order to improve response time in stationary equipment corrective maintenance can be viewed in **Table 28**.

Influence type	Process steps	Influence factors	Influence on BA			Influence on competitive objectives								Prioritization
			Elevator	Mining equipment	IT hardware	Costs	Speed	Flexibility	Safety	Dependa-bility	Security	Prevention	Quality	
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information	x	x	x	x	x	x		x		x	x	A
		Offering remote help/service	x	x	x	x	x	x	x	x		x	x	A
		Experience/knowledge/know-how	x	x	x	x	x	x	x	x		x	x	A
		Pre-identification through operators/on-site technicians of customer		x		x	x	x	x	x		x	x	A
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)	x	x	x	x	x	x	x	x				C
		Technicians located on-site (direct access/little travelling)	x	x	x	x	x	x	x	x				C
		Prioritization of jobs/dispatching/planning	x	x	x	x	x	x	x	x				C
		Routing/scheduling	x		x	x	x	x		x				C
		Availability of key boxes on-site	x			x	x	x		x	x			C
		Availability of facility management/(security) personnel on-site	x		x	x	x	x		x	x			C
		Access to units in high security areas (safety/health tests, etc.)	x	x	x	x	x	x		x	x			C
		Visa requirements		x		x	x	x		x				C
		Cars not equipped with navigation systems/GPS	x		x	x	x	x	x	x				C
		Language barriers and cultural differences		x		x	x			x				C
	Diagnosis (on-site)	Availability of diagnostic tools	x	x	x	x	x	x	x	x		x	x	A
		Availability of diagnostic intelligence structures	x	x	x	x	x	x	x	x		x	x	A
		Too quick diagnosis and thus not identifying the entire issue	x			x	x			x		x	x	A
		Availability of high quality spare parts catalogs/manuals	x	x	x	x	x	x		x			x	A
		Availability of electronic devices/support	x	x	x	x	x	x		x		x	x	A
		Information/barcodes/RFID/scanning functions on spare parts	x		x	x	x	x	x	x			x	A
		Information on customer/unit/other information	x	x	x	x	x	x	x	x		x	x	A
		Expert structures to identify issues/spare parts	x	x	x	x	x	x		x		x	x	A
		Experience/knowledge/know-how	x		x	x	x	x	x	x		x	x	A
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)	x	x	x	x	x	x		x				B
		Availability of car stock/site stock	x	x	x	x	x	x	x	x				B
		Availability of stock location network with quick deliveries	x	x	x	x	x	x		x				B
		Complexity of ordering process (electronical/paperless vs. manual)	x	x	x	x	x	x		x				B
		Ordering the right part(s)	x		x	x	x	x		x			x	A
		Availability of old parts and missing alternatives	x			x	x	x		x			x	A
		Availability of third-party parts	x			x	x	x		x			x	A
		Availability of custom made spare parts		x		x	x	x		x			x	A
		Utilization of local purchasing options	x			x	x	x		x				B
	Receiving	Availability of different delivery options to be flexible	x	x	x	x	x	x	x	x				B
		Pick up of spare parts at warehouse	x		x	x	x	x		x				B
		Delivery to pickpoints/PUDOs	x		x	x	x	x		x				B
		Delivery to service technicians' vans/cars/trucks	x		x	x	x	x		x				B
		Delivery to site	x	x	x	x	x	x		x				B
		Availability of express/emergency deliveries	x	x	x	x	x	x	x	x				B
	Repairing	Experience/knowledge/know-how	x	x	x	x	x	x	x	x		x	x	A
		Availability of the right (quality) tools	x	x	x	x	x	x	x	x			x	A
		First time fixes as main goal/repair plan	x	x	x	x	x	x	x	x		x	x	A
		Temporary/alternative solutions		x	x	x	x	x	x	x		x	x	A
		Terms/conditions/liabilities/service level agreements/contractual agreements	x	x	x	x	x			x	x			B
		Module based exchange of parts			x	x	x	x	x	x		x	x	A
		Communication and exchange of information possibilities	x	x	x	x	x	x	x	x		x	x	A
Indirect/ Strategic influences	Strategic factors	Number of units under maintenance per service technician	x	x	x	x	x	x	x	x			x	A
		Number of service technicians to secure proximity to units	x	x	x	x	x	x	x	x			x	A
		Training possibilities	x	x	x	x	x	x	x	x		x	x	A
		Fluctuation of service technicians/scarcity of qualified technicians	x	x	x	x	x	x	x	x	x		x	A
		Out-of-office times	x		x	x	x	x	x	x				B
		Top management attention for corrective maintenance/service oriented mindset within the company	x	x	x	x	x	x	x	x			x	A
		Keeping up to pace with market trends	x		x	x	x	x		x		x	x	A
		(Intrinsic) motivation of service technicians	x	x	x	x	x	x	x	x		x	x	A
Other influences	Non-influenceable circumstances	Traffic jams	x		x	x	x	x	x	x				B
		Weather conditions	x	x	x	x	x	x	x	x				B
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)	x	x	x	x	x	x	x	x				B
		Laws/regulations/customs	x	x		x	x	x	x	x				B

Table 28: Baseline for prioritization of factors affecting response time in stationary equipment corrective maintenance

Based on the analyses conducted, the focus should mainly be on direct/operational factors. Here, especially remote diagnosis can have a major impact on the overall response time, as it may eliminate all other corrective maintenance process steps except for the repair. In a third step, a focus on factors that affect speed/timeliness, quality and dependability should be made.

It is important to state, however, that furthermore, individual adaptations can and should be made. On the one hand this means to include individual focus points with respect to the competitive objectives, as explained before. Also, on the other hand, it is important to state that just because an overall focus on operational/direct factors has been observed and perceived to have a higher impact than strategic factors, for instance, these should not be neglected. The same is true for process steps other than remote diagnosis. Even though this may have the highest impact on the overall response time, improvements in other process steps should not be neglected as they may have substantial benefits as well. The utilization of the consensus construct thereby should specifically focus on the individual needs. If, for instance, a company feels that it is already very well equipped in terms of remote diagnosis, but lacks performance in other areas, e.g. ordering and receiving, than these process steps should be focussed on.

Additionally, the focus of an individual company can be to improve just one specific area, for instance repairs, or it can be to improve the entire corrective maintenance process. The same prioritization method should always apply, as focussing on every factors simultaneously generally is restricted by costs, resources, time, capabilities, etc. With an individual focus on ordering, for example, it can be seen that out of the nine factors listed, four are categorized in the highest priority group (A), and five are categorized in the second highest priority group (B). In order to improve this process step, a focus on the factors in priority A is suggested, i.e. ordering the right part(s), availability of old parts and missing alternatives, availability of third-party parts, and availability of custom made spare parts, before a focus on priority B may be considered. In the process step of on-site diagnosis, where all nine factors are listed in priority group A, the individual needs of the company are important to further prioritize. If safety were to be one of the major differentiators for the company, for instance, availability of diagnostic tools, availability of diagnostic intelligence structures, information, barcodes, RFID and scanning functions on spare parts, information on customer, units and other information, as well as experience, knowledge and know-how should be prioritized over the other factors. If safety and prevention were to be highly important for the company, then information, barcodes, RFID and scanning functions would be removed from highest priority to second highest priority.

The same is true, if the overall process including or excluding strategic factors, for instance, would be looked at. In order to utilize the resources, money, time and capabilities available, a focus on the most important factors per process step based on the consensus construct as well as the individual needs of the utilizer provides a thorough baseline for focus areas to improve in order to satisfy the customer and thus to remain and to become competitive.

Overall, it can be seen that this consensus construction with respect to influence factors forms the baseline for prioritizations. It needs to be dealt with on an individual level in business practice, however, in order to fully receive the benefits that it provides. Thereby, the baseline construction is flexible and can be adjusted in order to provide different viewpoints, further factors as well as adjustments to the competitive objectives affected by certain factors.

4.3.6.3 Prioritization of improvement possibilities/solutions

In order to react to the factors identified, the analyses provided in the previous chapters offer a large number of improvement possibilities derived from the case study research conducted.

In order to filter, validate and to prioritize the potential solutions to improve factors affecting the service technicians with respect to corrective maintenance response time for stationary equipment, a combination of two tools is utilized. The first tool to filter from the multitude of potential solutions is to check on must criteria (Lunau, Meran, John, Staudter and Roenpage, 2013), which needs to be fulfilled in order for the solutions to be implemented regardless of anything else. This filter method therefore, according to the authors, should be used before utilizing any other filtering method, as they erase or validate a solution based on compliance with essential criteria. These criteria include complying with the law, being safe, fulfilling customer needs, being aligned with the company strategy, fulfilling norms and standards, environmental compliance, etc. Every potential solution must be checked against these (or a selection of these) must criteria based on necessity. Only the solutions that comply with the must criteria can be used for further filtering. Non-compliance leads to rejection and no further consideration of a solution. An exemplary overview of this filter on the identified solutions can be seen in **Table 29**.

Solution Number	Solutions/ improvement possibilities	Must criteria		
		Legal	Safe	...
1	Smart questioning manuals/instructions, e.g. perfect call descriptions	y	y	...
2	Service centre trainings	y	y	...
3	Back-up equipment of certain units/parts to support in error identification remotely	y	y	...
4	Increase remote service/assistance focus	y	y	...
5	Install experienced technicians in remote positions	y	y	...
6	Sensors/preventive software/systems with error possibility notifications	y	y	...
7	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.	y	y	...
8	Visit new customers/units to retrieve all necessary information	y	y	...
9	Service centres in close proximity to major service markets	y	y	...
10	Geo-tracking	y	y	...
11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	y	y	...
12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	y	y	...
13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	y	y	...
14	Two passports per service technician, if necessary	y	y	...
15	Navigation system/GPS in every car	y	y	...
16	Language/intercultural trainings	y	y	...
17	High quality diagnostic tools	y	y	...
18	Third-party equipment diagnostic tools	y	y	...
19	Image recognition software for mobile devices (such as Google glasses)	y	y	...
20	Augmented reality applications, that show information on parts/units	y	y	...

Table 29: Exemplary extract overview of must criteria filter on identified solutions

This filter, especially in business practice is very important, as some regulations and laws apply in certain countries, whilst they do not in others. Even on a business level, some solutions, e.g. monitoring the service technicians' performance, geo-tracking or delivering spare parts into the service technicians' cars may be against regional laws or company policies, union agreements, etc. and thus need to be filtered out at this stage.

Once these mandatory criteria have been covered, the second tool to be used to filter and prioritize solutions in this consensus construction is the classical effort/cost-benefit matrix concept (Lunau et al, 2013). With this concept, according to the authors, solutions are prioritized based on the expected and perceived effort and/or cost of implementation versus the benefit that is expected to come out of the implementation. The scale thereby goes in ten steps from very high (+++++) effort/cost as well as benefit, to very low (-----) effort/cost as well as benefit. The more data and knowledge is available, the more accurate is the outcome of this tool. It is therefore recommended to do this exercise together with experts rather than by oneself. Once the ratings both for effort/cost as well as benefit have been conducted, the improvement opportunity can be placed in the effort/cost-benefit matrix accordingly (see **Figure 46**).

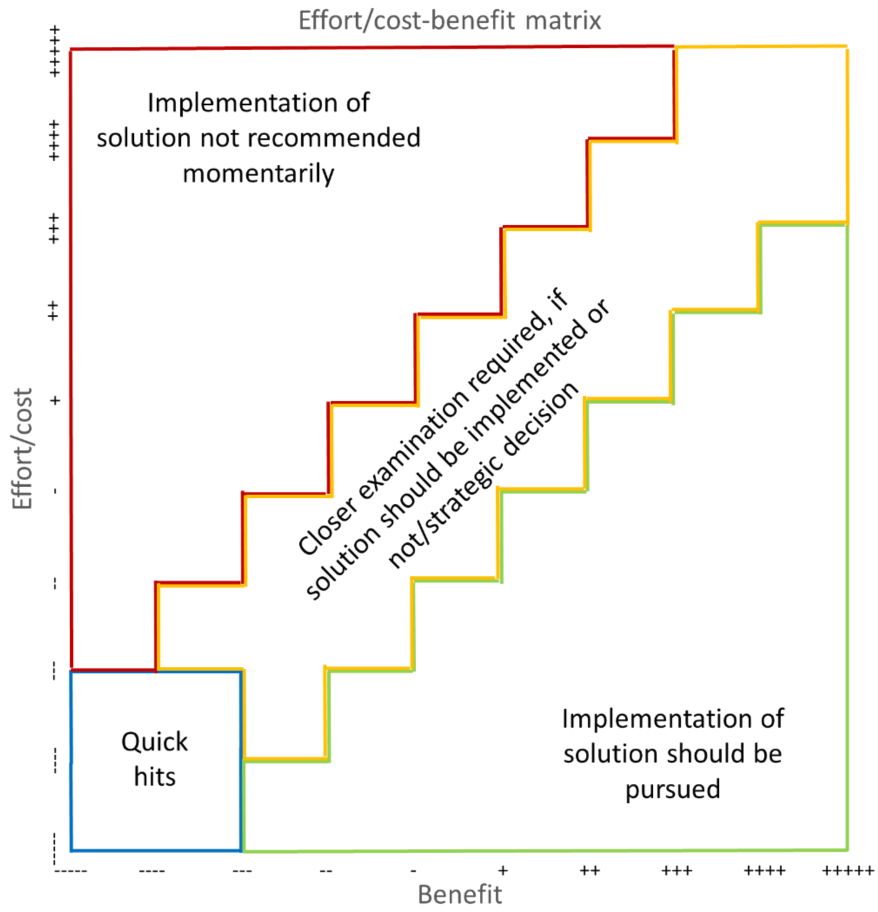

Figure 46: Effort/cost-benefit matrix (Own extended figure based on Lunau et al, 2013)

Depending on where the solution is placed, which again is based on the ratings both on effort/cost as well as benefit, a recommendation for action can be given. In cases, where the effort/cost is relatively small and the benefit is comparably high, the solution/improvement opportunity will end up in the green area of the diagram and implementation of the solution should be pursued. Contrary, if a solution were rated to generate potentially small benefits, however, the efforts and/or costs of implementing it are comparably high, an implementation of the solution cannot be recommended momentarily (red area). This does not mean, however, that this solution should never be considered. It simply means that in the current situation and based on the knowledge and information available, the effort/cost outweighs the positive impact it may have. If in the future this may change, however, e.g. because a technical solution becomes much cheaper to be implemented, then a reconsideration should be made.

A third category (yellow area) is available for solutions with fairly even ratings on effort/cost as well as benefits. Hence, here a closer examination is recommended to decide whether or not an implementation is suitable, before a final decision can be made. Also in this category, strategic decisions by the management, etc. can be made in favour or disfavour of a solution. An exception to this category are quick hits (blue area). Even though, solutions in this area have comparably even ratings with respect to effort/cost and benefits as well, both the costs/efforts and the benefits are generally very small, solutions are obvious and easy rescission can be obtained. Therefore, these solutions are recommended to be implemented right away.

If a more conservative version of the effort/cost-benefit matrix is preferred, the matrix can easily be altered in order to expand the yellow area, which implies further examination and evaluation is recommended before a final decision can be made. In this case, the quick hit area (blue area) is enlarged as well. The areas, where a clear implementation of solutions is recommended (green area) or not recommended (red area), become smaller accordingly. Graphically displayed, the effort/cost-benefit matrix then changes its layout as seen in **Figure 47**.

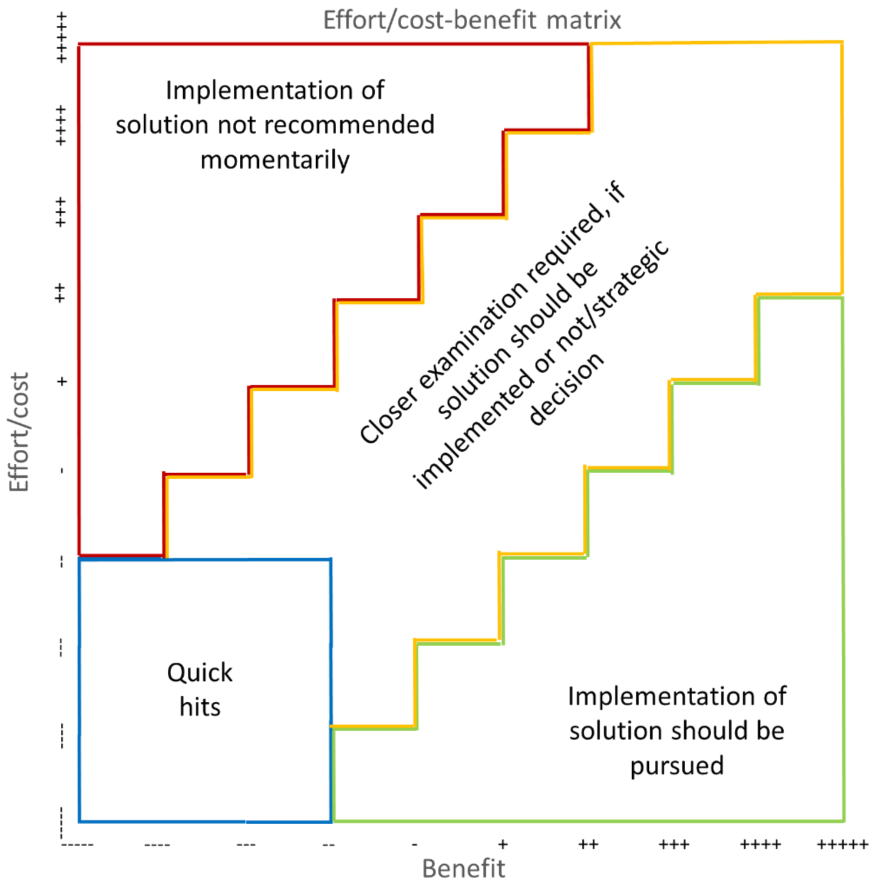

Figure 47: Conservative version of effort/cost-benefit matrix (Own extended figure based on Lunau et al, 2013)

In accordance with this part of the methodology, the identified 87 different solutions to improve service technicians' response time in corrective maintenance for stationary equipment (see **Table 24**), were both rated on effort/cost to implement as well as on the benefit expected to be provided. For this exercise, the standard effort/cost-benefit matrix was used. The ratings are based on the information received during the case study research as well as a double check with the three company experts from the different business areas, who were involved as mentors in this doctorate. A graphical overview of the results is provided in **Figure 48**.

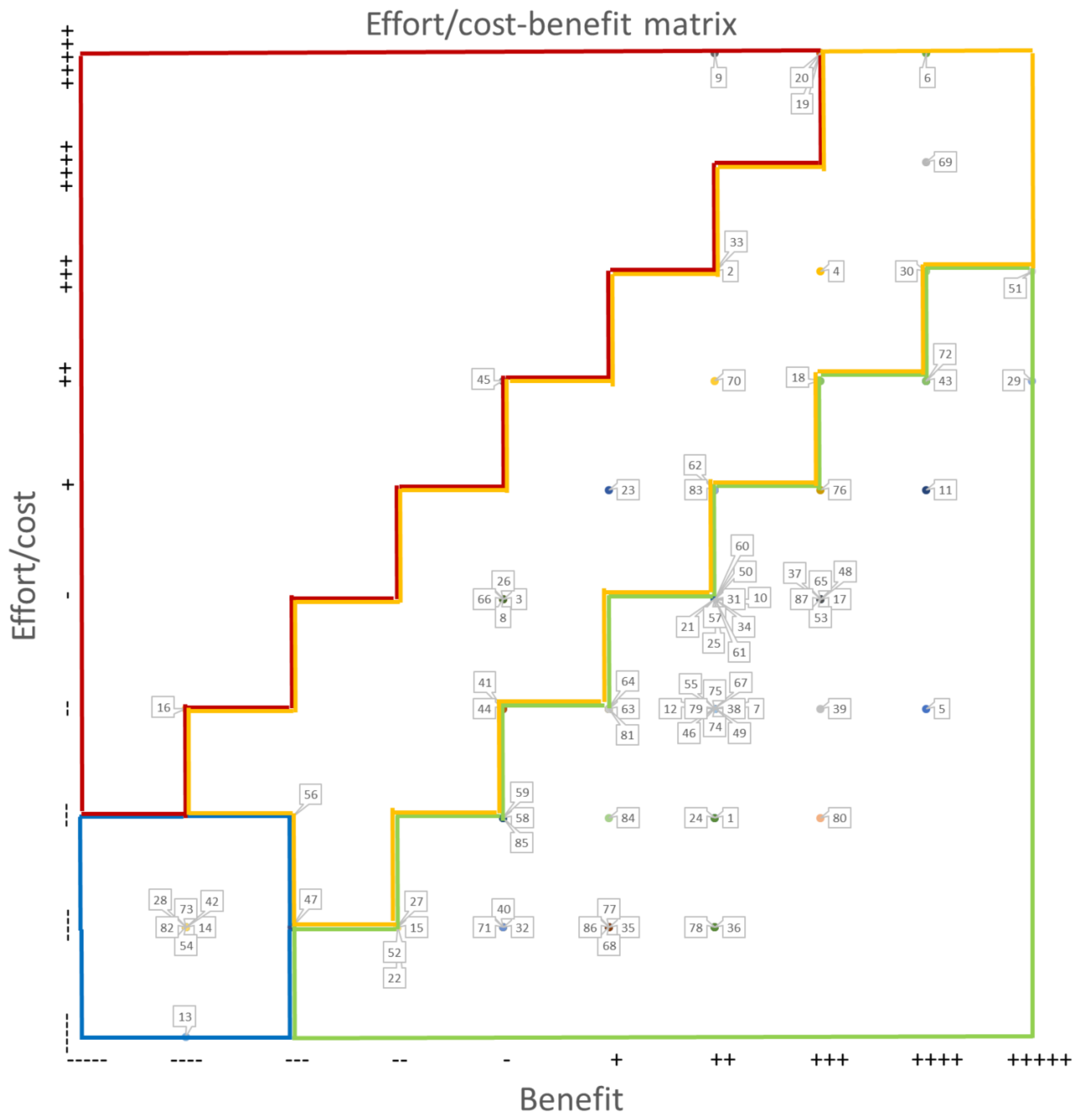

Figure 48: Effort/cost-benefit matrix for the 87 identified solutions to improve service technicians' response time in corrective maintenance for stationary equipment

Based on the ratings for the consensus construction, a total of 56 out of the 87 different solutions are recommended to be pursued. An additional seven quick hits are also recommended to be implemented. Another 19 out of the 87 different solutions, according to the consensus construction, need further examination or a strategic input before a final decision is recommended to be made. The remaining five solutions are recommended to not be implemented momentarily and should be re-evaluated at a later stage, if appropriate.

For an overview of the ratings and recommendations per solution please refer to **Table 30**.

Solution Number	Solutions/ improvement possibilities	Must criteria			Effort/cost of solution	Benefit of solution	Recommen-dation for action
		Legal	Safe	...			
1	Smart questioning manuals/instructions, e.g. perfect call descriptions	y	y	...	---	++	Implementation should be pursued
2	Service centre trainings	y	y	...	+++	++	Closer examination/strategic decision
3	Back-up equipment of certain units/parts to support in error identification remotely	y	y	...	-	-	Closer examination/strategic decision
4	Increase remote service/assistance focus	y	y	...	+++	+++	Closer examination/strategic decision
5	Install experienced technicians in remote positions	y	y	...	--	++++	Implementation should be pursued
6	Sensors/preventive software/systems with error possibility notifications	y	y	...	+++++	++++	Closer examination/strategic decision
7	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.	y	y	...	--	++	Implementation should be pursued
8	Visit new customers/units to retrieve all necessary information	y	y	...	-	-	Closer examination/strategic decision
9	Service centres in close proximity to major service markets	y	y	...	+++++	++	Implementation not recommended momentarily
10	Geo-tracking	y	y	...	-	++	Implementation should be pursued
11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	y	y	...	+	++++	Implementation should be pursued
12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	y	y	...	--	++	Implementation should be pursued
13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	y	y	...	-----	----	Quick hit
14	Two passports per service technician, if necessary	y	y	...	----	----	Quick hit
15	Navigation system/GPS in every car	y	y	...	----	--	Implementation should be pursued
16	Language/intercultural trainings	y	y	...	--	----	Implementation not recommended momentarily
17	High quality diagnostic tools	y	y	...	-	+++	Implementation should be pursued
18	Third-party equipment diagnostic tools	y	y	...	++	+++	Closer examination/strategic decision
19	Image recognition software for mobile devices (such as Google glasses)	y	y	...	+++++	+++	Implementation not recommended momentarily
20	Augmented reality applications, that show information on parts/units	y	y	...	+++++	+++	Implementation not recommended momentarily
21	RFID/Scanning functions on mobile devices	y	y	...	-	++	Implementation should be pursued
22	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.	y	y	...	----	--	Implementation should be pursued
23	Access units remotely through clouds	y	y	...	+	+	Closer examination/strategic decision
24	Online/electronical spare parts catalogs/manuals available on mobile devices	y	y	...	---	++	Implementation should be pursued
25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices	y	y	...	-	++	Implementation should be pursued
26	3D-drawings/explosion drawings were necessary in catalog on mobile devices	y	y	...	-	-	Closer examination/strategic decision
27	Multiple pictures from various angles per spare part in catalog on mobile devices	y	y	...	----	--	Implementation should be pursued
28	Regular updates of catalog on mobile devices	y	y	...	----	----	Quick hit
29	Mobile device for every service technician	y	y	...	++	+++++	Implementation should be pursued
30	Strong IT-/ERP-support	y	y	...	+++	++++	Closer examination/strategic decision
31	Unique parts numbers that match with information in catalog on mobile devices	y	y	...	-	++	Implementation should be pursued
32	Additional information on spare parts that matches with information in catalog on mobile devices	y	y	...	----	-	Implementation should be pursued
33	RFID/Scanning functions on spare parts	y	y	...	+++	++	Closer examination/strategic decision
34	Bill of matierial per unit	y	y	...	-	++	Implementation should be pursued
35	Easy exchange of information and pictures in chat functions on mobile devices	y	y	...	----	+	Implementation should be pursued
36	Different technicians/support levels for different issues	y	y	...	----	++	Implementation should be pursued
37	Specialization trainings	y	y	...	-	+++	Implementation should be pursued
38	Regular technical trainings (knowledge building and refreshments)	y	y	...	--	++	Implementation should be pursued
39	Customer management/orientation trainings	y	y	...	--	+++	Implementation should be pursued
40	Paperless approvals through mobile devices	y	y	...	----	-	Implementation should be pursued
41	Install fast track ordering process in urgent cases, where usually, due to the price of the spare parts, three offers would be needed	y	y	...	--	-	Closer examination/strategic decision
42	Clear approval processes/structures implemented	y	y	...	----	----	Quick hit
43	Automatic car stock replenishment through mobile device bookings/statistics	y	y	...	++	++++	Implementation should be pursued
44	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates	y	y	...	--	-	Closer examination/strategic decision
45	Automatic stock location replenishment through software	y	y	...	++	-	Implementation not recommended momentarily

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46	Mobile device should show nearest available stock location for each part	y	y	...	--	++	Implementation should be pursued
47	In emergencies, make use of parts produced for new installations (manufacturing centres)	y	y	...	--	++	Implementation should be pursued
48	Web shop for direct ordering via mobile device	y	y	...	-	+++	Implementation should be pursued
49	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device	y	y	...	--	++	Implementation should be pursued
50	Paperless orders/bookings through RFID/scanning functions on mobile device	y	y	...	-	++	Implementation should be pursued
51	3D-printing	y	y	...	+++	+++++	Implementation should be pursued
52	Clear identification/diagnosis processes	y	y	...	----	--	Implementation should be pursued
53	Supplier relationship management for a network with quick delivery times	y	y	...	-	+++	Implementation should be pursued
54	Allowing local purchases with easy processes in situations, where other options are not as good	y	y	...	----	----	Quick hit
55	Create a flexible delivery concept with multiple options for the technicians/customers to pick from	y	y	...	--	++	Implementation should be pursued
56	Possibility to pick up parts at warehouse, if necessary, and pre-notification through mobile devices	y	y	...	---	---	Closer examination/strategic decision
57	Possibility to have parts delivered to pick points/PUDOs through mobile devices	y	y	...	-	++	Implementation should be pursued
58	Reliable forwarders	y	y	...	---	-	Implementation should be pursued
59	Forwarders with extensive network of pickpoints/PUDOs	y	y	...	---	-	Implementation should be pursued
60	Possibility to have parts delivered into cars/vans/trucks through mobile devices	y	y	...	-	++	Implementation should be pursued
61	Possibility to have parts delivered to site through mobile devices	y	y	...	-	++	Implementation should be pursued
62	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices	y	y	...	+	++	Closer examination/strategic decision
63	Repair kits with standard tools	y	y	...	--	+	Implementation should be pursued
64	Repair kits with standard parts for certain issues	y	y	...	--	+	Implementation should be pursued
65	High quality and light tools	y	y	...	-	+++	Implementation should be pursued
66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office	y	y	...	-	-	Closer examination/strategic decision
67	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device	y	y	...	--	++	Implementation should be pursued
68	Agreements should be dealt with by back office and not affect service technician	y	y	...	----	+	Implementation should be pursued
69	Design platform based units to reduce the number of parts	y	y	...	++++	++++	Closer examination/strategic decision
70	Design module based solutions	y	y	...	++	++	Closer examination/strategic decision
71	Utilize/hire service technicians from other business areas	y	y	...	----	-	Implementation should be pursued
72	Monitor service technicians performance (where possible) in order to point out improvement opportunities	y	y	...	++	++++	Implementation should be pursued
73	Mirror training needs with actual trainings received regularly	y	y	...	----	----	Quick hit
74	Administrative trainings	y	y	...	--	++	Implementation should be pursued
75	Softskill trainings	y	y	...	--	++	Implementation should be pursued
76	Incentivize technicians	y	y	...	+	+++	Implementation should be pursued
77	Beware of technicians' needs	y	y	...	----	+	Implementation should be pursued
78	Incorporate technicians' knowledge	y	y	...	----	++	Implementation should be pursued
79	Motivate technicians through trainings, etc.	y	y	...	--	++	Implementation should be pursued
80	Safety focus, e.g. through dead-man-function	y	y	...	---	+++	Implementation should be pursued
81	Install emergency service for out-of-office times according to service level agreements	y	y	...	--	+	Implementation should be pursued
82	Install globally used KPI to measure service response time	y	y	...	----	----	Quick hit
83	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher networking capital)	y	y	...	+	++	Closer examination/strategic decision
84	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings	y	y	...	---	+	Implementation should be pursued
85	Communicate new products/production stops to after-sales service department structured and well in advance	y	y	...	---	-	Implementation should be pursued
86	Make use of and monitor customer feedback	y	y	...	----	+	Implementation should be pursued
87	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly	y	y	...	-	+++	Implementation should be pursued

Table 30: Ratings and recommendations per solution/improvement opportunity

If instead of the approach chosen, the earlier described conservative effort/cost-benefit matrix were to be used in business practice, the split of recommendations for the solutions with the same ratings would look slightly different.

In this setting, a shift towards the recommendation for closer examinations on solutions can be seen. A total of 44 out of the 87 different solutions are now in this category. Despite the conservative approach, however, a total of 33 solutions still receive the recommendation for implementation and nine solutions can now be categorized as quick hits. Only one solution is not recommended to be implemented at this point of time based on the ratings on efforts/costs as well as benefits expected. A graphical overview of these results, which include the same ratings as in the context stated above, as well as the recommendations generated based on the conservative effort/cost-benefit matrix approach can be found in **Appendix 7** and **Appendix 8** respectively.

In addition to the two tools used to prioritize the solutions/improvement opportunities, furthermore, the individual preferences of the company or business area utilizing this approach should be applied. This can be achieved by finding a mix between solutions that focus on the three previously identified categories, i.e. technical assistance, back office support, and enabling the service technician. Thereby all three categories may be strengthened simultaneously and a too particular focus on a certain area may be avoided.

Furthermore, the must criteria list can be adjusted in order to fit to the circumstances and business needs. Additionally, two versions of the effort/cost benefit matrix are provided to suit both conservative and more progressive strategies. Further potential possibilities of structuring the effort/cost-benefit matrix can also be produced. Also, additional solutions may be added to the construct or solutions can be erased from the list based on the company or business area needs. The ratings for the solutions, which in this construction are the outcome of the empirical research, as described before, can be used as a general overview and recommendation applicable to business practice in the community studied. When adjusting the ratings with respect to the individual needs, a more independent overview of the solutions for the factors affecting service technicians in corrective maintenance response time for stationary equipment can, however, always be generated.

As for the influence factors, also for the optimization potentials/solutions, it has to be stated that due to restrictions such as investments, resources, willingness to change, etc., the simultaneous pursuit of all recommendations is not possible. The three aspects covered in this chapter (i.e. must criteria, effort/cost-benefit matrix, mix of individualized preferences) help prioritizing and individualizing the needs of the company or business area using this consensus construct. Based on the baselines created with respect to both factors as well as improvement potentials, the combination of the two areas specifies action recommendations even further. This will be covered in the next chapter therefore.

4.3.6.4 Merging the prioritization results to generate action recommendations

Incorporating both the prioritizations of factors as well as solutions basically acts as a final filter before action can be taken.

When looking at the outcome of the standard effort/cost-benefit matrix, a total of 56 solutions is recommended to be pursued to improve all factors. Even though this might be extremely beneficial to the corrective maintenance process in theory, in business practice it is very unlikely that investments, manpower efforts needed, other resources and willingness to change, etc. are available to handle this amount of changes simultaneously. Therefore, by including the prioritization results of the factors as a filter, an implementation plan can be generated to work on each of the items in a structured order.

To start with, obviously the factors with the highest influence on the service technicians with regards to response time in the corrective maintenance process should be worked on. The user of the construct, regardless of that being a business area or a company within a business area, has the choice of either tackling the overall most important factors in the entire process, or, if seen as more appropriate, tackling the most important factors in each process step or a selection of process steps, with remote diagnosis being identified as the main lever. This can also include a focus on strategic factors, as seen in **Chapter 4.3.6.2**.

If the decision is to look at the factors that seem to have the highest impact on the process overall, the highest prioritized factors, i.e. with focus on speed/timeliness, quality and dependability, based on the consensus construction results can be picked. Again here, it is up to the user of the construct to decide on whichever number of factors seems appropriate to work on at a time. Also it is up to the end-user to decide, if further prioritizations based on individual needs, e.g. for security, safety or other competitive advantages should be included for a more granular and individualized result.

Based on the decisions with regards to factors to be developed and improved, the user will then be presented a set of solutions that help to overcome the issues and improve response time in the corrective maintenance process. These solutions are prioritized and show clear action recommendations thereby. Here again, individual settings to the tool, such as including specific must criteria, etc. additionally help for a utilization that is beneficial to the final outcome based on the needs of the utilizer.

Once a final (first) set of solutions to be implemented has been retrieved from this consensus construct, as mentioned before, a clearly structured implementation plan to assign clear roles, milestones, targets and deadlines, to monitor the implementation process as well as to continuously check on the sustainability of effects, etc. should be constructed for the solutions (Lunau et al, 2013). Second and third tier solutions may additionally be added to the implementation plan to show the improvements as part of a multi-generation-plan over time (Lunau et al, 2013).

Overall, if this consensus construct is applied in business practice, regardless of how many factors can be tackled at a time or how many solutions can be implemented at a time based on the company or business area involved, an improved performance in corrective maintenance should always become visible as the construct provides an overview of the factors with the highest impact on the response time and the solutions with the most favourable effort/cost involved to generate the most favourable benefits. Therefore, even if only one solution for one factor and thus process step were to be worked on, the highest individual possible improvement available from one solution on the process should be the end result. Based on the needs and possibilities of companies and/or business areas, the consensus construct can both be used to retrieve an overview and make use of all possibilities to improve the process of corrective maintenance for stationary equipment smartly and generally in order to reduce technicians' response times, as well as it beholds possibilities for punctual optimizations based on the possibility to quickly identify the best solutions for each factor or the factors mostly affecting the response time in the corrective maintenance process.

It can be seen that this consensus construction lays a foundation for action in order to improve service technicians' performance in corrective maintenance with respect to service response time for stationary equipment in the community studied. It is flexible and adjustable to the individual needs of the person, people, companies or business areas using it and it provides a guideline and recommendations on where to take action. Here again, flexibility and individuality are given to the end user by deciding on how many points to focus on at a time and what to specifically include in the construct.

The combination of all results regarding the perceived factors and solutions from this empirical research to be used as a reference or starting point for individualization of the consensus construction based on business area or company specific needs is displayed in **Table 31**.

Influence type	Process steps	Influence factors	Ran-king	Solu-tion	Solutions/improvement possibilities	Improvement area	Must criteria			Effort/cost of solution	Benefit of solution	Recommendation for action
							Legal	Safe	...			
Direct/ operational influences	Diagnosis (remotely)	Intelligent questioning to retrieve information	A	1	Smart questioning manuals/instructions, e.g. perfect call descriptions	Back office support	y	y	...	---	++	Implementation should be pursued
				2	Service centre trainings	Enabling technician	y	y	...	+++	++	Closer examination/strategic decision
				3	Back-up equipment of certain units/parts to support in error identification remotely	Technical assistance	y	y	...	-	-	Closer examination/strategic decision
		Offering remote help/service	A	1	Smart questioning manuals/instructions, e.g. perfect call descriptions	Back office support	y	y	...	---	++	Implementation should be pursued
				4	Increase remote service/assistance focus	Back office support	y	y	...	+++	+++	Closer examination/strategic decision
				3	Back-up equipment of certain units/parts to support in error identification remotely	Technical assistance	y	y	...	-	-	Closer examination/strategic decision
		Experience/knowledge/know-how	A	5	Install experienced technicians in remote positions	Enabling technician	y	y	...	--	++++	Implementation should be pursued
				2	Service centre trainings	Enabling technician	y	y	...	+++	++	Closer examination/strategic decision
		Pre-identification through operators/on-site technicians of customer	A	1	Smart questioning manuals/instructions, e.g. perfect call descriptions	Back office support	y	y	...	---	++	Implementation should be pursued
				6	Sensors/preventive software/systems with error possibility notifications	Technical assistance	y	y	...	+++++	++++	Closer examination/strategic decision
				3	Back-up equipment of certain units/parts to support in error identification remotely	Technical assistance	y	y	...	-	-	Closer examination/strategic decision
	Driving to/accessing the unit	Travelling to the unit (proximity to unit)	C	47	In emergencies, make use of parts produced for new installations (manufacturing centres)	Back office support	y	y	...	--	++	Implementation should be pursued
				8	Visit new customers/units to retrieve all necessary information	Back office support	y	y	...	-	-	Closer examination/strategic decision
				9	Service centres in close proximity to major service markets	Back office support	y	y	...	+++++	++	Implementation not recommended momentarily
		Technicians located on-site (direct access/little travelling)	C	7	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.	Back office support	y	y	...	--	++	Implementation should be pursued
		Prioritization of jobs/dispatching/planning	C	10	Geo-tracking	Technical assistance	y	y	...	-	++	Implementation should be pursued
				11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	Technical assistance	y	y	...	+	++++	Implementation should be pursued
		Routing/scheduling	C	10	Geo-tracking	Technical assistance	y	y	...	-	++	Implementation should be pursued
				11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	Technical assistance	y	y	...	+	++++	Implementation should be pursued
		Availability of key boxes on-site	C	12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance	y	y	...	--	++	Implementation should be pursued
		Availability of facility management/(security) personnel on-site	C	12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance	y	y	...	--	++	Implementation should be pursued
		Access to units in high security areas (safety/health tests, etc.)	C	13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	Back office support	y	y	...	-----	----	Quick hit
		Visa requirements	C	13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	Back office support	y	y	...	-----	----	Quick hit
				14	Two passports per service technician, if necessary	Enabling technician	y	y	...	----	----	Quick hit
		Cars not equipped with navigation systems/GPS	C	15	Navigation system/GPS in every car	Technical assistance	y	y	...	----	--	Implementation should be pursued
		Language barriers and cultural differences	C	16	Language/intercultural trainings	Enabling technician	y	y	...	--	----	Implementation not recommended momentarily
	Diagnosis (on-site)	Availability of diagnostic tools	A	17	High quality diagnostic tools	Technical assistance	y	y	...	-	+++	Implementation should be pursued
				18	Third-party equipment diagnostic tools	Technical assistance	y	y	...	++	+++	Closer examination/strategic decision
				19	Image recognition software for mobile devices (such as Google glasses)	Technical assistance	y	y	...	+++++	+++	Implementation not recommended momentarily
				20	Augmented reality applications, that show information on parts/units	Technical assistance	y	y	...	+++++	+++	Implementation not recommended momentarily
				21	RFID/Scanning functions on mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				22	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.	Technical assistance	y	y	...	----	--	Implementation should be pursued
		Availability of diagnostic intelligence structures	A	23	Access units remotely through clouds	Technical assistance	y	y	...	+	+	Closer examination/strategic decision
				6	Sensors/preventive software/systems with error possibility notifications	Technical assistance	y	y	...	+++++	++++	Closer examination/strategic decision

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		Too quick diagnosis and thus not identifying the entire issue	A	24	Online/electronical spare parts catalogs/manuals available on mobile devices	Technical assistance	y	y	...	---	++	Implementation should be pursued
				25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				26	3D-drawings/explosion drawings were necessary in catalog on mobile devices	Technical assistance	y	y	...	-	-	Closer examination/strategic decision
				27	Multiple pictures from various angles per spare part in catalog on mobile devices	Technical assistance	y	y	...	----	--	Implementation should be pursued
				28	Regular updates of catalog on mobile devices	Technical assistance	y	y	...	----	----	Quick hit
		Availability of high quality spare parts catalogs/manuals	A	24	Online/electronical spare parts catalogs/manuals available on mobile devices	Technical assistance	y	y	...	---	++	Implementation should be pursued
				25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				26	3D-drawings/explosion drawings were necessary in catalog on mobile devices	Technical assistance	y	y	...	-	-	Closer examination/strategic decision
				27	Multiple pictures from various angles per spare part in catalog on mobile devices	Technical assistance	y	y	...	----	--	Implementation should be pursued
				28	Regular updates of catalog on mobile devices	Technical assistance	y	y	...	----	----	Quick hit
		Availability of electronic devices/support	A	29	Mobile device for every service technician	Technical assistance	y	y	...	++	+++++	Implementation should be pursued
				30	Strong IT-/ERP-support	Technical assistance	y	y	...	+++	++++	Closer examination/strategic decision
		Information/barcodes/RFID/scanning functions on spare parts	A	31	Unique parts numbers that match with information in catalog on mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				32	Additional information on spare parts that matches with information in catalog on mobile devices	Technical assistance	y	y	...	----	-	Implementation should be pursued
				33	RFID/Scanning functions on spare parts	Technical assistance	y	y	...	+++	++	Closer examination/strategic decision
		Information on customer/unit/other information	A	34	Bill of matierial per unit	Technical assistance	y	y	...	-	++	Implementation should be pursued
				12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance	y	y	...	--	++	Implementation should be pursued
		Expert structures to identify issues/spare parts	A	35	Easy exchange of information and pictures in chat functions on mobile devices	Technical assistance	y	y	...	----	+	Implementation should be pursued
				36	Different technicians/support levels for different issues	Enabling technician	y	y	...	----	++	Implementation should be pursued
		Experience/knowledge/know-how	A	37	Specialization trainings	Enabling technician	y	y	...	-	+++	Implementation should be pursued
				16	Language/intercultural trainings	Enabling technician	y	y	...	--	----	Implementation not recommended momentarily
				38	Regular technical trainings (knowledge building and refreshments)	Enabling technician	y	y	...	--	++	Implementation should be pursued
				39	Customer management/orientation trainings	Enabling technician	y	y	...	--	+++	Implementation should be pursued
	Ordering	Approval process for spare parts ordering (necessary or not; electronical/paperless vs. manual)	B	40	Paperless approvals through mobile devices	Technical assistance	y	y	...	----	-	Implementation should be pursued
				41	Install fast track ordering process in urgent cases, where usually, due to the price of the spare parts, three offers would be needed	Back office support	y	y	...	--	-	Closer examination/strategic decision
				42	Clear approval processes/structures implemented	Back office support	y	y	...	----	----	Quick hit
		Availability of car stock/site stock	B	43	Automatic car stock replenishment through mobile device bookings/statistics	Technical assistance	y	y	...	++	++++	Implementation should be pursued
				44	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates	Back office support	y	y	...	--	-	Closer examination/strategic decision
		Availability of stock location network with quick deliveries	B	45	Automatic stock location replenishment through software	Technical assistance	y	y	...	++	-	Implementation not recommended momentarily
				46	Mobile device should show nearest available stock location for each part	Technical assistance	y	y	...	--	++	Implementation should be pursued
				47	In emergencies, make use of parts produced for new installations (manufacturing centres)	Back office support	y	y	...	--	++	Implementation should be pursued
		Complexity of ordering process (electronical/paperless vs. manual)	B	48	Web shop for direct ordering via mobile device	Technical assistance	y	y	...	-	+++	Implementation should be pursued
				49	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device	Technical assistance	y	y	...	--	++	Implementation should be pursued
				50	Paperless orders/bookings through RFID/scanning functions on mobile device	Technical assistance	y	y	...	-	++	Implementation should be pursued
		Ordering the right part(s)	A	51	3D-printing	Technical assistance	y	y	...	+++	+++++	Implementation should be pursued
				52	Clear identification/diagnosis processes	Back office support	y	y	...	----	--	Implementation should be pursued
		Availability of old parts and missing alternatives	A	51	3D-printing	Technical assistance	y	y	...	+++	+++++	Implementation should be pursued
				53	Supplier relationship management for a network with quick delivery times	Back office support	y	y	...	-	+++	Implementation should be pursued
		Availability of third-party parts	A	51	3D-printing	Technical assistance	y	y	...	+++	+++++	Implementation should be pursued
				53	Supplier relationship management for a network with quick delivery times	Back office support	y	y	...	-	+++	Implementation should be pursued
		Availability of custom made spare parts	A	51	3D-printing	Technical assistance	y	y	...	+++	+++++	Implementation should be pursued
				53	Supplier relationship management for a network with quick delivery times	Back office support	y	y	...	-	+++	Implementation should be pursued
		Utilization of local purchasing options	B	54	Allowing local purchases with easy processes in situations, where other options are not as good	Back office support	y	y	...	----	----	Quick hit

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	Receiving	Availability of different delivery options to be flexible	B	55	Create a flexible delivery concept with multiple options for the technicians/customers to pick from	Back office support	y	y	...	--	++	Implementation should be pursued
		Pick up of spare parts at warehouse	B	56	Possibility to pick up parts at warehouse, if necessary, and pre-notification through mobile devices	Technical assistance	y	y	...	---	---	Closer examination/strategic decision
		Delivery to pickpoints/PUDOs	B	57	Possibility to have parts delivered to pick points/PUDOs through mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				58	Reliable forwarders	Back office support	y	y	...	---	-	Implementation should be pursued
				59	Forwarders with extensive network of pickpoints/PUDOs	Back office support	y	y	...	---	-	Implementation should be pursued
		Delivery to service technicians' vans/cars/trucks	B	60	Possibility to have parts delivered into cars/vans/trucks through mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				58	Reliable forwarders	Back office support	y	y	...	---	-	Implementation should be pursued
		Delivery to site	B	61	Possibility to have parts delivered to site through mobile devices	Technical assistance	y	y	...	-	++	Implementation should be pursued
				58	Reliable forwarders	Back office support	y	y	...	---	-	Implementation should be pursued
		Availability of express/emergency deliveries	B	62	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices	Technical assistance	y	y	...	+	++	Closer examination/strategic decision
	Repairing	Experience/knowledge/know-how	A	37	Specialization trainings	Enabling technician	y	y	...	-	+++	Implementation should be pursued
				16	Language/intercultural trainings	Enabling technician	y	y	...	--	----	Implementation not recommended momentarily
				38	Regular technical trainings (knowledge building and refreshments)	Enabling technician	y	y	...	--	++	Implementation should be pursued
				39	Customer management/orientation trainings	Enabling technician	y	y	...	--	+++	Implementation should be pursued
		Availability of the right (quality) tools	A	63	Repair kits with standard tools	Technical assistance	y	y	...	--	+	Implementation should be pursued
				64	Repair kits with standard parts for certain issues	Technical assistance	y	y	...	--	+	Implementation should be pursued
				65	High quality and light tools	Technical assistance	y	y	...	-	+++	Implementation should be pursued
		First time fixes as main goal/repair plan	A	66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office	Back office support	y	y	...	-	-	Closer examination/strategic decision
				23	Access units remotely through clouds	Technical assistance	y	y	...	+	+	Closer examination/strategic decision
		Temporary/alternative solutions	A	12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	Technical assistance	y	y	...	--	++	Implementation should be pursued
				66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office	Back office support	y	y	...	-	-	Closer examination/strategic decision
		Terms/conditions/liabilities/service level agreements/contractual agreements	B	67	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device	Technical assistance	y	y	...	--	++	Implementation should be pursued
				68	Agreements should be dealt with by back office and not affect service technician	Back office support	y	y	...	----	+	Implementation should be pursued
		Module based exchange of parts	A	69	Design platform based units to reduce the number of parts	Back office support	y	y	...	++++	++++	Closer examination/strategic decision
				70	Design module based solutions	Back office support	y	y	...	++	++	Closer examination/strategic decision
		Communication and exchange of information possibilities	A	35	Easy exchange of information and pictures in chat functions on mobile devices	Technical assistance	y	y	...	----	+	Implementation should be pursued

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Strategic influences	Strategic factors	Number of units under maintenance per service technician	A	37	Specialization trainings	Enabling technician	y	y	...	-	+++	Implementation should be pursued
		Number of service technicians to secure proximity to units	A	36	Different technicians/support levels for different issues	Back office support	y	y	...	----	++	Implementation should be pursued
				71	Utilize/hire service technicians from other business areas	Back office support	y	y	...	----	-	Implementation should be pursued
		Training possibilities	A	72	Monitor service technicians performance (where possible) in order to point out improvement opportunities	Enabling technician	y	y	...	++	++++	Implementation should be pursued
				73	Mirror training needs with actual trainings received regularly	Enabling technician	y	y	...	----	----	Quick hit
				37	Specialization trainings	Enabling technician	y	y	...	-	+++	Implementation should be pursued
				38	Regular technical trainings (knowledge building and refreshments)	Enabling technician	y	y	...	--	++	Implementation should be pursued
				74	Administrative trainings	Enabling technician	y	y	...	--	++	Implementation should be pursued
				75	Softskill trainings	Enabling technician	y	y	...	--	++	Implementation should be pursued
				16	Language/intercultural trainings	Enabling technician	y	y	...	--	----	Implementation not recommended momentarily
				39	Customer management/orientation trainings	Enabling technician	y	y	...	--	+++	Implementation should be pursued
		Fluctuation of service technicians/scarcity of qualified technicians	A	76	Incentivize technicians	Enabling technician	y	y	...	+	+++	Implementation should be pursued
				77	Beware of technicians' needs	Enabling technician	y	y	...	----	+	Implementation should be pursued
				78	Incorporate technicians' knowledge	Enabling technician	y	y	...	----	++	Implementation should be pursued
				79	Motivate technicians through trainings, etc.	Enabling technician	y	y	...	--	++	Implementation should be pursued
				80	Safety focus, e.g. through dead-man-function	Enabling technician	y	y	...	---	+++	Implementation should be pursued
				71	Utilize/hire service technicians from other business areas	Back office support	y	y	...	----	-	Implementation should be pursued
		Out-of-office times	B	81	Install emergency service for out-of-office times according to service level agreements	Back office support	y	y	...	--	+	Implementation should be pursued
		Top management attention for corrective maintenance/service oriented mindset within the company	A	82	Install globally used KPI to measure service response time	Back office support	y	y	...	----	----	Quick hit
				83	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher networking capital)	Back office support	y	y	...	+	++	Closer examination/strategic decision
		Keeping up to pace with market trends	A	84	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings	Enabling technician	y	y	...	---	+	Implementation should be pursued
				85	Communicate new products/production stops to after-sales service department structured and well in advance	Back office support	y	y	...	---	-	Implementation should be pursued
				86	Make use of and monitor customer feedback	Back office support	y	y	...	----	+	Implementation should be pursued
				87	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly	Back office support	y	y	...	-	+++	Implementation should be pursued
		(Intrinsic) motivation of service technicians	A	72	Monitor service technicians performance (where possible) in order to point out improvement opportunities	Enabling technician	y	y	...	++	++++	Implementation should be pursued
				76	Incentivize technicians	Enabling technician	y	y	...	+	+++	Implementation should be pursued
				77	Beware of technicians' needs	Enabling technician	y	y	...	----	+	Implementation should be pursued
				78	Incorporate technicians' knowledge	Enabling technician	y	y	...	----	++	Implementation should be pursued
				79	Motivate technicians through trainings, etc.	Enabling technician	y	y	...	--	++	Implementation should be pursued
				80	Safety focus, e.g. through dead-man-function	Enabling technician	y	y	...	---	+++	Implementation should be pursued
Other influences	Non-influenceable circumstances	Traffic jams	B	Not (or only hardly) influenceable: Should be covered through improvements that can be influenced, e.g. routing, proximity to units and navigation systems/GPS to avoid traffic jams, driving long distances or in heavy terrain, etc.								
		Weather conditions	B									
		Infrastructure (geographically: big cities vs. remote islands or mountain regions, etc.; company-wise: spread out portfolio of units)	B									
		Laws/regulations/customs	B									

Table 31: Consensus construction recommendations for action overview based on prioritization of factors and improvement opportunities

Overall, based on the findings generated through the research as well as the development of the consensus construction, a general set of three utilization opportunities can be formulated to cater for different needs. These options are:

1. General information and utilization: Using the overall findings of this research for an overview of perceived factors influencing service technicians with respect to corrective maintenance response time for stationary equipment as well as perceived corresponding improvement opportunities, both rated and prioritized to generate a utilization order for the community studied.

2. Individualization: Besides looking at the generated outcomes of this research, the consensus construction can always be adjusted to company or business area specific individualized needs. Prioritization for factors and solutions can be altered based on individual viewpoints and a choice of a standard or more conservative effort/cost-benefit matrix as well must criteria specifics can be applied in order to cater to individual needs.

3. Add-ons: To specify and individualize the outcomes even further, company or business area specific factors and/or solutions can be added and deleted for a maximum outcome of individualized results.

Of course, the more individualization is required or aimed for, the higher is the effort for the individual user of the construct. Whilst the first option can be utilized immediately, quickly and easily without any additional work, the user will work with general findings based on the research of three business areas.

If, however, more individualization is required, the second and third options offer respective possibilities. Here, the more individualization is required, the higher efforts to adjust and adapt the construction are required as well, however. The flexibility of the consensus construction for the community studied allows for all levels of effort to cater the needs of each individual user to generate valuable output for business practice utilization.

The applicability of the findings as well as the consensus construction for the community involved in this research has been cross-checked and validated by the three company experts involved in the entire process of this research as well as the university supervisors. The contributions and findings of this chapter are displayed and summarized in **Figure 49**.

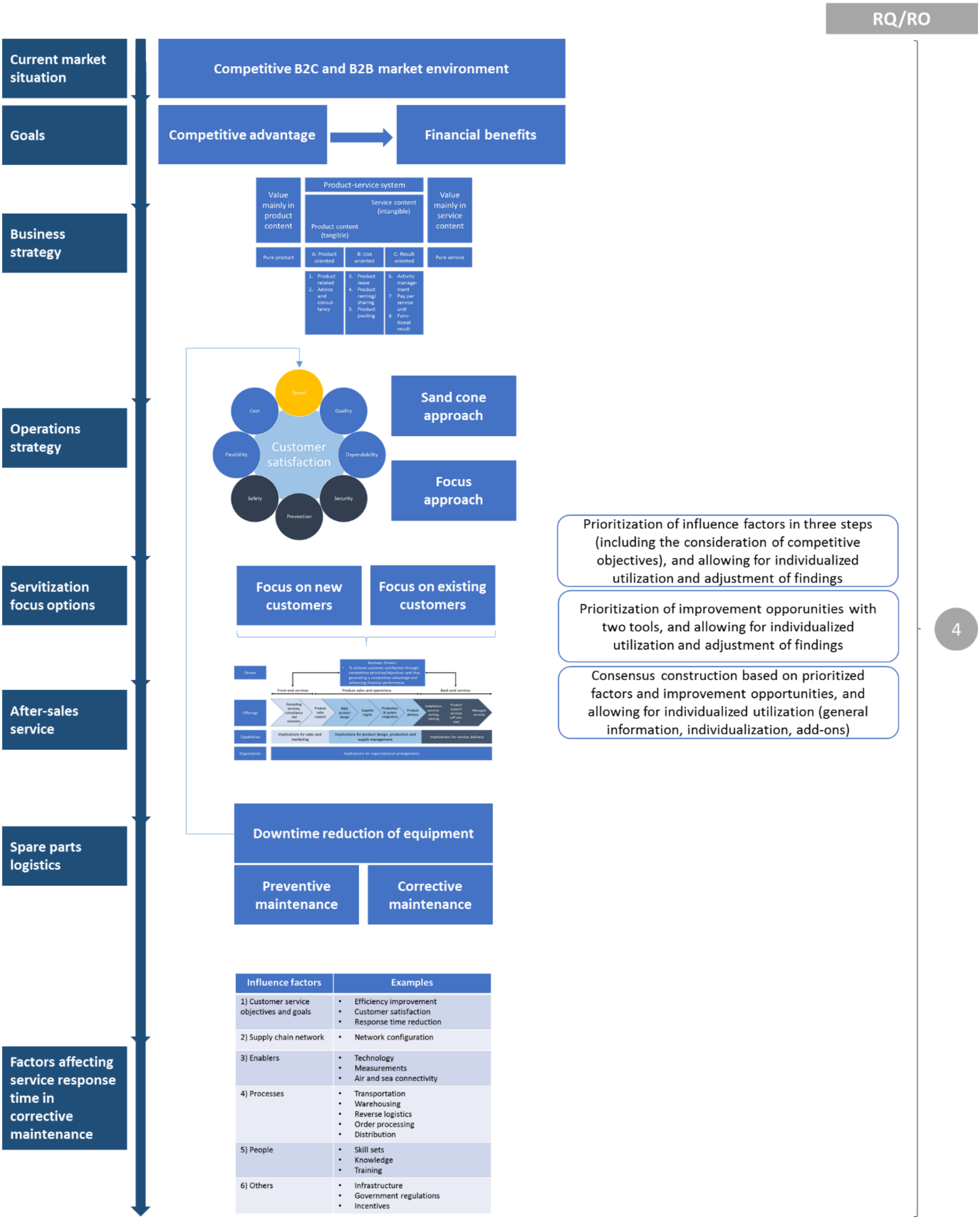

Figure 49: Extract of extended Figure 24, showing the contributions to RQ/RO 4

4.4 Phase 4: Conclusions, limitations, outlook and recommendations

4.4.1 Introduction

As displayed in **Figure 28** and introduced in **Chapter 3.4.2.5**, this chapter concludes the findings generated in this thesis and provides an overview of the contributions realized by conducting this research. It further displays the limitations of this thesis and it gives an outlook for further research as well as recommendations.

These conclusions are based on the findings of the entire thesis, i.e. the theoretical identification of a gap in research, as well as the empirical research to contribute to closing it. As with every phase in the authors research, the results of this phase have been cross-checked and validated by the two university supervisors as well as the business experts involved in this research.

This chapter is divided into six sub-chapters. Following this introduction, the methodological approach is explained, before the results, frameworks and constructs from the literature review and empirical research phase are connected. Based on this, in the fourth sub-chapter it is the aim to reflect upon the contribution to knowledge through this thesis. The fifth sub-chapter is aimed to highlight the contribution of this thesis to business practice, and finally, the sixth sub-chapter will deal with limitations of this research as well as and outlook and recommendations of opportunities for further research.

4.4.2 Methodological approach

The empirical research has produced a large amount of data, which was described, summarized, prioritized and connected into a consensus construction for the community studied in the previous chapters. In this final chapter of the thesis, the outcomes will therefore be reflected and concluded. This provides the last step in the framework provided by Miles et al (2014). Whilst conclusions were drawn throughout all phases of the research, these were kept to a minimum, as suggested by the authors, up to this stage in order to draw full conclusions based on the entirety of results generated.

To accommodate this, the framework generated during the literature view, which describes the path towards identifying the research questions as well as research objectives (**Chapter 1** and **Chapter 2**), and an overview of the outcomes of the empirical research, which develop the consensus construction (**Chapter 4**), are shown and connected. Furthermore, connections between the concepts explained during the literature review as well as the context generated during the empirical research phase are drawn. Overall, these provide the contributions of this thesis and research both to knowledge as well as business practice, which are explained in detail.

The results are thereby based around the cornerstones of validity, reliability and generalizability (Easterby-Smith et al, 2012) as well as credibility, dependability, confirmability and transferability (Lincoln et al, 1985) to provide robust outcomes. Credibility, as stated by Lincoln et al (1985) and validity, as stated by Easterby-Smith et al (2012), thereby aim at ensuring that enough perspectives have been included in the research. Having included three different cases, i.e. elevator, mining equipment, and IT hardware, based on the theoretical sampling approach (Glaser et al, 1967), multiple different sources of input, i.e. data analyses, process observations, and in-depth interviews that have been triangulated, as well as experts from different regions, strategic and operational backgrounds, etc., which have been chosen through a combination of snowball and opportunistic sampling (Patton, 2002), provided a large bandwidth of data that has shown credibility and validity of data. Numerous examples, different perspectives and information were utilized to generate the consensus construction for the community studied.

Dependability, as stated by Lincoln et al (1985) as well as reliability, as mentioned by Easterby-Smith et al (2012) also have a similar goal. Both deal with ensuring that the results observed in this research could also be achieved similarly by another researcher. A data base with records as well as auditing mechanisms were installed by the author in order to assure this. Experts both from the university as well as the different business areas were asked to validate the data during multiple milestones and phases throughout the entire research. Generalizability, as described by Easterby-Smith et al (2012) as well as transferability, as described by Lincoln et al (1985) and Bryman et al (2011), in qualitative research aims at a detailed description of the community-based knowledge generation to provide a baseline to interested audiences to judge independently on how the knowledge can be transferred to each individual case. By giving different application recommendations for the consensus construction, the construct provides a baseline for utilization of the generated data on very individualized requirements and needs. Lastly, confirmability, as described by Lincoln et al (1985) aims at ensuring robust data through the minimization of biases. These have been addressed in **Chapter 3.5** and closely been monitored throughout the entire research.

Based on these criteria, the research provides robust and valid data that may be utilized both in business practice as well as for further research. While these contributions are explained, limitations to the research as well as an outlook and recommendations for further research are also addressed in this context as well in order to provide a full picture and placing of the research in the overall context. Limitations thereby deal with multiple layers. They occur with regards to the chosen research philosophy as well as the research methodology applied. Furthermore, the context of the research, research questions and research objectives, which deal with a very specific topic, may entail certain limitations. These will be explained, and an outlook and recommendations based around these will be given in order to ensure they are addressed in future research.

4.4.3 Connecting the literature review and the empirical research results

As previously explained, the literature review provided an identification of numerous gaps in literature. However, the most urgent need for additional research has been identified with respect to the corrective maintenance response time and the perceived factors that affect service technicians in this context, especially in B2B industries and for stationary equipment. The according overview framework as well as the gaps identified are explained in **Chapter 2.4** and **Figure 23**. Based on this context, four research questions and four research objectives that contribute to closing the gap have also been identified and explained in **Chapter 2.4** and **Figure 24** respectively. This is displayed in **Figure 50**.

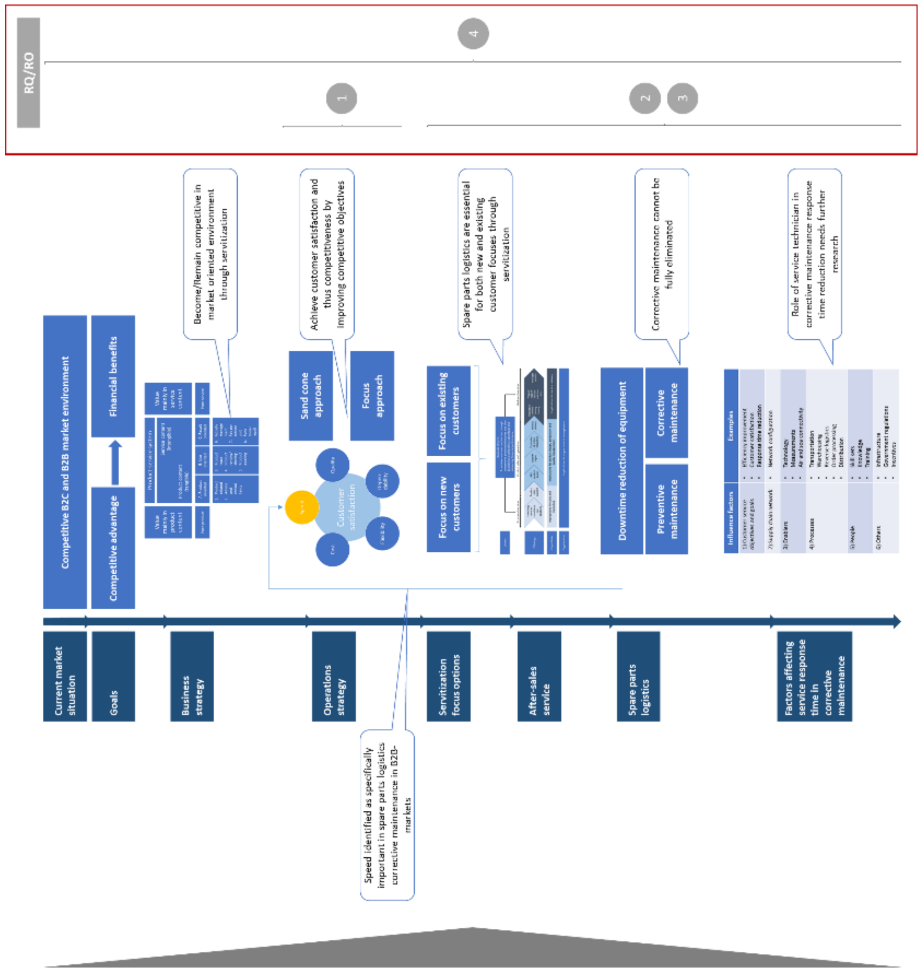

Figure 24

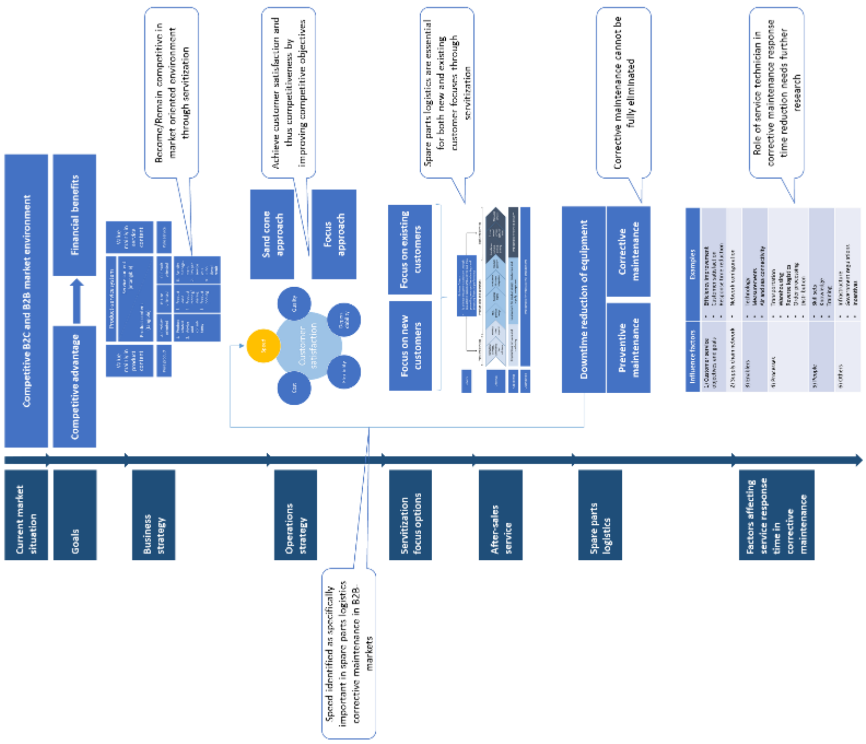

Figure 23

Figure 50: Framework constructed based on literature review as well as development of framework with regards to research questions and research objectives

Based on this framework, in the empirical research (**Chapter 4**) and based on the according research philosophy, methodology and design (**Chapter 3**), all four research questions and research objectives have been addressed in detail accordingly. The results have been shown in extracts that add onto the framework constructed in **Figure 23** respectively **Figure 24** throughout **Chapter 4.3**. A full overview of the contributions is therefore shown in **Figure 51**.

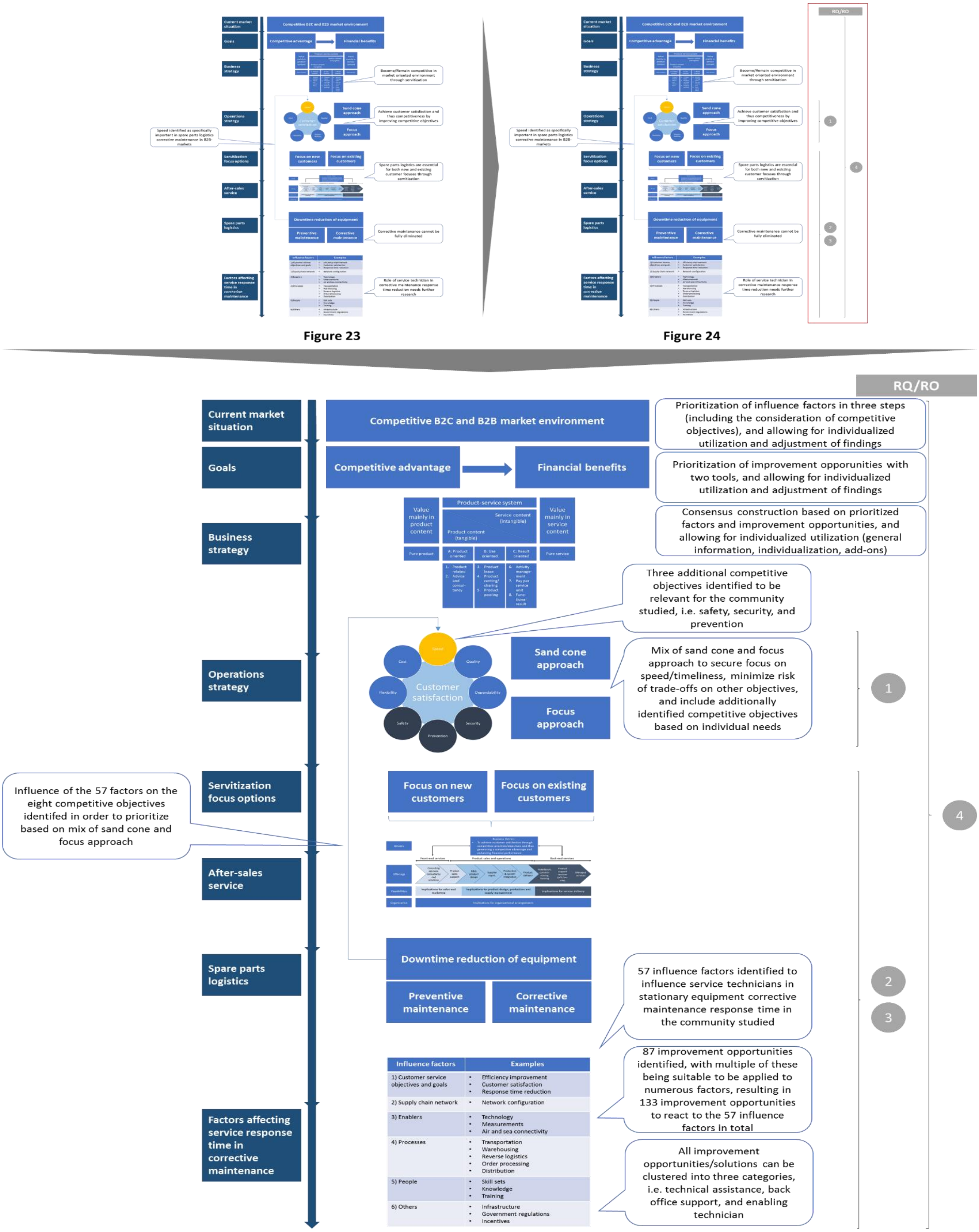

Figure 51: Overview of contributions derived through expanding the framework generated as part of the literature review by adding knowledge generated through the empirical research

Each research question and research objective thereby contributes to the overall goal of improving response time in stationary equipment corrective maintenance in the community studied, thereby generating opportunities to satisfy the customers and remain and/or become competitive in the respective markets and industries.

In more depth, the contributions both to knowledge as well as business practice are explained in the next chapters.

4.4.4 Contributions to knowledge

Firstly, by conducting an in-depth literature review and identifying an area for further research need, two major contributions to knowledge have been generated.

On the one hand and as displayed in **Figure 23** respectively **Figure 24**, the literature review has helped to gradually isolate an area with research needs. Among numerous potential gaps identified in the different areas of de Souza et al's (2011) framework, which have been explained in **Chapter 2.3.3.3** to **Chapter 2.3.3.8** and summarized in **Chapter 2.4**, especially the need for further research with regards to stationary equipment corrective maintenance response time and the perceived factors that affect service technicians in this process has been identified to provide needs for research. By conducting the research for this thesis based on the identified gap, further requirements for research in this area became evident that will have to be dealt with in separate research endeavours. Recommendations are displayed in **Chapter 4.4.6**.

On the other hand, numerous theoretical concepts, for instance the relationship between operations management and strategy as well as business strategy, the concepts of PSS, servitization, the service paradox, the role of spare parts management in service and the importance of downtime reduction in corrective maintenance through improved service response times as well as perceived factors affecting the response time in corrective maintenance have thereby been reviewed in-depth, put into context and displayed in a structured way.

Secondly, when looking at the research outcomes, it can be seen that knowledge contributions to these concepts have been made throughout this research as well. A contribution to the widely accepted PSS categorization (e.g. Baines et al, 2009; Weissenberger-Eibl et al, 2010; Wang, Ming, Li, Kong, Wang and Wu, 2011; Bezerra Barquet et al, 2013) of Tukker (2004) (see **Figure 12**), for instance, can be seen in the fact that the research outcomes of this thesis are applicable to companies operating in all three product-service systems stated by him. Namely, these are product oriented companies, which add services to their products based on the customer need, use oriented companies, where equipment ownership remains with the manufacturer while the customer pays for the use of the equipment, as well as result oriented companies, which offer flexible performance based models for customers to use equipment or use outsourced services from third parties. These were represented by the chosen diversity of companies in the case study analyses of this research. Despite their differences, they all have in common that their success revolves around functioning equipment and end units. Regardless of risk-sharing, involvement of third-party providers or the influence of the OEM on the product, the final goal of all equipment owners is to have functioning equipment. Overall, this research generates an opportunity for companies and business areas to improve the performance of PSS and thus satisfying the customer, i.e. through response time reduction in corrective maintenance for stationary equipment.

The same is true for a contribution of knowledge through this research to the concept of servitization, which deals with the aim of companies trying to transfer their business from product manufacturers to a higher focus on customer satisfaction by adding services to their products, which otherwise would be standalone solutions (e.g. Vandermerwe et al, 1988; Gebauer, 2007; Gebauer et al, 2012). Regardless of the servitization maturity level of a company in the community studied, i.e. the level to which this transfer has been conducted in a company or business area, the consensus construction of this thesis can be applied. Whilst it was seen in this research, for instance, that the mining equipment business area is less mature in terms of servitization compared to the elevator business area, which again is less mature than the IT hardware business area, the need for functioning equipment and quick response times in corrective maintenance are equally important in all sectors, thus contributing knowledge to the context.

An additional contribution to knowledge has been achieved by providing further insights into the six categories of de Souza et al’s (2011) framework (see **Table 1**) with respect to the context of this research. As the literature review revealed, especially the factors of processes and people showed further potential for research. By developing and answering the research questions as well as fulfilling the research objectives in order to contribute to closing the gap in this area, knowledge has been generated that contributes to de Souza et al’s (2011) factors of people and processes, i.e. by investigating competitive objectives of, influencing factors on and identifying improvement opportunities to help and support service technicians in corrective maintenance for stationary equipment. In the other areas of de Souza et al’s framework, as mentioned before, further gaps were identified that need to be worked on as part of other research endeavours.

Furthermore, the three business areas, i.e. elevator, mining equipment and IT hardware were studied in-depth, providing a valuable overview that contributes to knowledge. With regards to the competitive objectives, this doctoral research showed that Slack et al’s (2014) five key objectives flexibility, cost, speed, quality and dependability, which all aim on the main goal of satisfying the customer, are fully applicable in corrective maintenance for stationary equipment in the community studied as well. Also, three additional objectives were identified to be applicable in this context. Namely these objectives are safety and prevention as well as security. This shows, that even though response time, i.e. speed, is very important and also the main focus of this research, the other seven competitive objectives cannot be neglected when outstanding customer satisfaction through corrective maintenance is aimed to be achieved in corrective maintenance for stationary equipment. Concepts, such as the sand cone model (Ferdows et al, 1990; Slack et al, 2014) as well as the focus approach (Slack et al, 2014) need to be considered in order to minimize the risk of trade-offs, while aiming to improve speed/timeliness, i.e. response time. The combined applicability of these concepts for the community studied as well as the adaption of including the eight competitive objectives identified in this context provide a further contribution to knowledge.

Besides the core competitive objectives in corrective maintenance for stationary equipment, contributions to knowledge also resulted out of the identification of perceived factors that affect the service technician as well as perceived improvement opportunities to optimize the response time in corrective maintenance for stationary equipment. Overall, a comprehensive list of 57 perceived factors and a total of 87 perceived improvement opportunities to react to these factors were identified. As some of the perceived improvement opportunities affect more than one factor, a total of 133 possible solutions was generated. These perceived factors and improvement opportunities were clustered based on the process steps (based on Cohen et al, 1997) as well as levers, i.e. operational/direct, strategic/indirect, and others/non-influenceable circumstance, in order to provide a structure and a baseline for prioritizations and the consensus construction for further utilization in the community studied. The structures and concepts applied for a prioritization of the factors as well as the improvements in connection with the competitive objectives thereby provide a further contribution to knowledge.

In order to apply the consensus construction, three application recommendations that provide utilization of the general results of this research and/or steps in order to individualize the construct based on the individual user requirements have been provided. By applying a mix of technical improvements, enablers for the service technicians as well as improvements in back office and/or supporting processes in order to react to the identified factors, a contribution to the general recommendations to improve logistics in different aspects simultaneously, i.e. technology, human resources and organization, as stated by Pfohl (2004), have been achieved as well.

Overall, with this research, a knowledge contribution to the originally stated trend towards an increased focus of companies on customer satisfaction in B2B industries (e.g. Christopher, 2010; Dölarslan, 2014; Politis et al, 2014; Ali et al, 2015) as well as a new opportunity to react to the need for companies to increase their competitive position based on Porter's (1985) concept of value addition and cost leadership has been achieved by providing a consensus construction to improve response time in corrective maintenance for stationary equipment in the community studied.

4.4.5 Contributions to business practice

Besides contributions to knowledge, contributions to business practice have also been achieved with this research.

In order to answer the research questions and to fulfil the research objectives, which are based around the identified gap in literature, three in-depth case studies provided insights into the topic from various angles. These inputs were transferred into a consensus construction which can be applied in business practice by the participants of this research in the community studied. In order to make the consensus construction utilizable in business practice, the construct is generated in a flexible manor in order to be used in different settings and under different circumstances.

Overall, the construction can be used in three different ways respectively adjusted to company or business area specific needs. The first option is to use the general results as they have been generated through this research. In the second and third options, the consensus construction, e.g. the prioritization, additional factors or improvement opportunities, the effort/cost-benefit matrix, etc. can be specifically adjusted to company or business area specific needs. It is therefore assured that individual needs and circumstances of users of the construction are covered. The more individualized results are required, the higher is the effort for the user of the construct by adjusting or rating and prioritizing the factors and improvement measures for their own purposes.

In addition to the consensus construction, through this research an improved awareness, understanding as well as transparency for the topic and its importance has been achieved. The experts and companies involved in this research were highly involved in the entire process and are very interested in the results and their utilization.

4.4.6 Limitations, outlook and recommendations

With regards to the research conducted and the consensus construction created, there are certain limitations, as explained in **Chapter 3.4.2.5**.

The first level of limitations thereby is created through the research philosophy, i.e. moderate social constructionism, as well as the research methodology, i.e. abductive, qualitative, multiple case study research (see **Chapter 3.2** and **Chapter 3.3**). Especially the fact that this research is based on a moderate social constructionist research philosophy thereby means that the applicability of the results is limited to the community involved in this research. Further research is necessary, if a generalization beyond the findings from this community is needed and desired. These results provide a baseline, however, that can be utilized in these cases. In this context, it can be stated that also within the community studied, differences and various viewpoints exist that may lead to differences in the application of the consensus construction. This has been incorporated into the research by giving application recommendations in order to individualize the utilization. The more individualization is required by a company or business area, however, the higher is the effort to use the consensus construction, which might pose a limitation to instant applicability in certain cases.

Furthermore, a second set of limitations within this research can be seen, as this research deals with only one of the gaps derived in the literature review. It thus focusses on a consensus construction in order to improve factors affecting service technicians in stationary equipment corrective maintenance response time. Additionally, within this context, a specific focus on B2B markets, corrective maintenance and its processes is looked at in three particular business areas. Other business areas, effects on B2C environments, non-stationary equipment, preventive maintenance, etc. are not focussed on specifically. Furthermore, the additionally identified research gaps throughout the literature review have not been covered by this thesis.

Also thirdly, in this research, and as previously mentioned, the choice of interviewees in the IT hardware business area poses a limitation. The number of experts selected fort this case is comparably lower than for the other two cases. While saturation of results could clearly be observed, a higher number of experts in this business area would have been more desirable in order to provide more data and inputs on a comparable number of participants.

Lastly, the developed consensus construction has not yet been implemented and tested in business practice. Whilst all the findings as well as the construction generation itself have been conducted in close cooperation with business experts from each business area involved in this research, an in-practice utilization has to be worked on in another research study. The given results have been verified and proven to be valid and robust. At this stage they can therefore be seen as a baseline to be used for further research to be conducted.

Further research may help to overcome these limitations. For instance, in order to test the consensus construction in business practice, the methodology of action research can be seen as the next reasonable research approach at this stage as it validates and contributes to knowledge based on changes in action (e.g. Coghlan, 2004; Reason and Bradbury, 2006; Bryman et al, 2011). In this case, the created construct could be tested in a company in one of the three different business areas involved in this research. Implementing this construction in a business area or company of choice and modifying it to the individual needs based on the guidelines and outcomes of this research will validate the usability of the general outcomes of the consensus construction. This could, of course, also be done in multiple different companies or business areas to generate further outcomes. It is recommended to start with a pilot, however, and roll out the research to multiple cases only after a first pilot has proven to be successful.

Additional research recommendations based on the knowledge acquired in this thesis and beyond the scope described before may also include the possibility for an additional focus on specific factors or improvement areas in more detail. This could, for example, mean to look at an in-depth investigation in remote assistance or on-site identification of errors/malfunctioning parts. It seems to also be feasible to look at the skills that technicians need in more detail. Here the recommendation would be to then include a differentiation between technical knowledge, administrative skills as well as soft skills. Also incentivizing and motivation are possible further topics with regards to service technicians and their performance, which are worth looking at in more detail. Especially useful and beneficial seem to also be more research endeavours in arising trends, e.g. using Google glasses as a diagnostic tool, utilization of big data and clouds for more remote services as well as prevention, the importance of Industry 4.0, 3D-printing, etc. with respect to corrective maintenance response time reduction for stationary equipment.

Also, a combination of the consensus construction of this research with other frameworks, e.g. SERVQUAL (Parasuraman et al, 1988) or SERVPERF (Cronin et al, 1992), for instance, in order to further strengthen the minimization of trade-offs with regards to the competitive objectives, could add value to the context. Furthermore, the relevance of this consensus construction for non-stationary equipment corrective maintenance response time reduction could be looked at and researched as well as the effects of the framework in B2C settings, the application in other business areas, etc.

To structure these possibilities, a suggested outline for future research is shown in **Figure 52**, including the expected, indicative effort to conduct it.

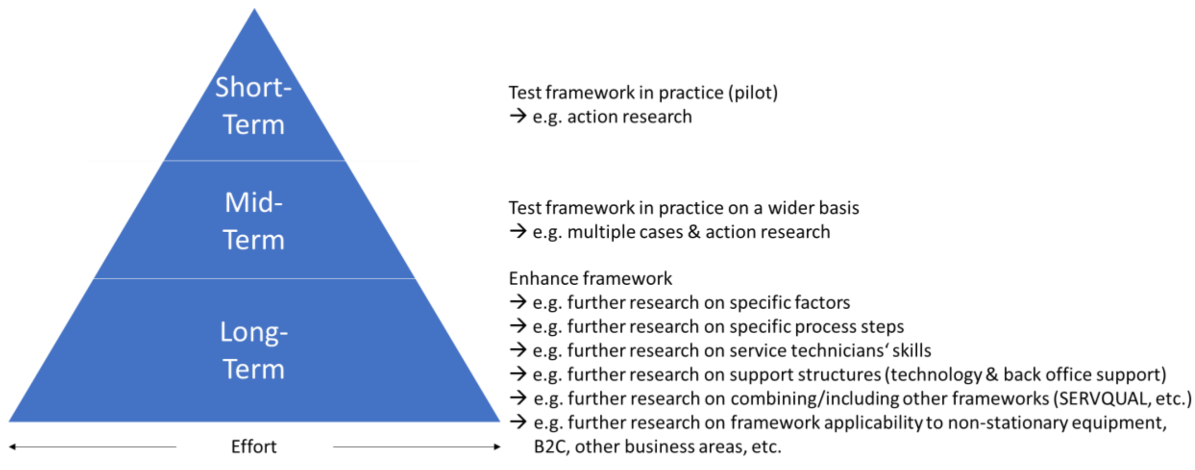

Figure 52: Proposed future research

Whilst the short-term goal of conducting a pilot is expected to include comparably low efforts, a wider roll out would obviously need more efforts and is therefore planned as a mid-term goal. To enhance the consensus construction on multiple levels will be a long-run task, as each one of the proposed items will need a high amount of research and effort in itself.

Bibliography

Ahamed, Z., Inohara, T., & Kamoshida, A. (2013). The Servitization of Manufacturing: An Empirical Case Study of IBM Corporation. International Journal of Business Administration, 4(2), 18-26.

Ahn, J. S., & Sohn, S. O. (2009). Customer pattern search for after-sales service in manufacturing. Expert Systems with Applications, 36, 5371-5375.

Ali, R., Leifu, G., Rafiq, M. Y., & Hassan, M. (2015). Role Of Perceived Value, Customer Expectation, Corporate Image And Perceived Service Quality On The Customer Satisfaction. The Journal of Applied Business Research, 31(4), 1425-1436.

Alshenqeeti, H. (2014). Interviewing as a Data Collection Method: A Critical Review. English Linguistics Research, 3(1), 39-45.

Alvarez, E. M. (2013). The Value of Customization on Differentiation in Service Logistics. (Ph.D.), University of Twente, Enschede.

Alvarez, R. L. P., Ramos Martins, M., & Terra da Silva, M. (2015). Applying the maturity model concept to the servitization process of consumer durables companies in Brazil. Journal of Manufacturing Technology Management, 26(8), 1086-1106.

Andrews, T. (2012). What is Social Constructionism? The Grounded Theory Review, 11(1), 39-46.

AON. (2012). Industry Analysis: IT Consulting and Services (pp. 1-22). London: AON.

Ariño, A., LeBaron, C., & Milliken, F. J. (2016). Publishing Qualitative Research in Academy of Management Discoveries. Academy of Management Discoveries, 2(2), 109-113.

Armstrong & Associates, Inc. (2010). Spare Parts Logistics: Quintessential Global Supply Chain Management - Market Size and Major Players (pp. 1-22). Stoughton, WI: Armstrong & Associates, Inc..

Avella, L., Vazquez-Bustelo, D., & Fernandez, E. (2011). Cumulative manufacturing capabilities: an extended model and new empirical evidence. International Journal of Production Research, 49(3), 707-729.

Avlonitis, V., Frandsen, T., Hsuan, J. & Karlsson, C. (2014). Driving Competitiveness Through Servitization: A Guide For Practicioners (pp. 1-24). Copenhagen: The CBS Competitiveness Platform.

Baader, A. (2014). Key initiatives for profitable growth in the Spare Parts Business. Presentation presented at the ISLA Service & Logistics Summit 2014, Frankfurt am Main.

Baader, A., Montanus, S., & Sfat, R. (2006). After Sales Services: mit produktbegleitenden Dienstleistungen profitabel wachsen. In Barkawi, K., Baader, A., & Montanus, S. (Ed.), Erfolgreich mit After Sales Services: Geschäftsstrategien für Servicemanagement und Ersatzteillogistik (pp. 3-14). Berlin: Springer.

Bacchetti, A., & Saccani, N. (2012). Spare parts classification and demand forecasting for stock control: Investigating the gap between research and practice. Omega, 40(6), 722-737.

Baines, T., Lightfoot, H., Peppard, J., Johnson, M., Tiwari, A., Shehab, E., & Swink, M. (2009). Towards an operations strategy for product-centric servitization. International Journal of Operations & Production Management, 29(5), 494-519.

Baines, T. S., Lightfoot, H., Steve, E., Neely, A., Greenough, R., Peppard, J., ..., & Wilson, H. (2007). State-of-the-art in product service-systems. Journal of Engineering Manufacture, 221, 1-10.

Baines, T., Ziaee Bigdeli, A., Bustinza, O. F., Guang Shi, V., Baldwin, J., & Ridgway, K. (2017). Servitization: revisiting the state-of-the-art and research priorities. International Journal of Operations & Production Management, 37(2), 256-278.

Baker, S. E., & Edwards, R. (2012). How many qualitative interviews is enough? Expert voices and early career reflections on sampling and cases in qualitative research (pp. 1-42). Southhampton: National Centre for Research Methods.

Barkawi & Partner GmbH & Co. KG. (2006). Excellence in Spare Parts Logistics: How to Cope with Growing Customers Expectations. Presentation presented at the Industry Round Table Automotive & Machinery, Gießen.

Barney, J. B. (1991). Firm Resources and Sustained Competitive Advantage. Journal of Management, 17(1), 99-120.

Barney, J. B. (2012). Purchasing, Supply Chain Management and Sustained Competitive Advantage: The Relevance of Resource-Based Theory. Journal of Supply Chain Management, 48(2), 3-6.

Barney, J. B., & Wright, P. M. (1998). On Becoming a Strategic Partner: The Role of Human Resources in Gaining Competitive Advantage. Human Resource Management, 37(1), 31-46.

Baumann, G., Baumgart, M., Geltinger, A., Kähler, V., Lewerenz, W., & Schliebner, I. (2010). Logistische Prozesse: Berufe der Lagerlogistik (16 ed.). Troisdorf: Bildungsverlag EINS.

Becker, J., Vilkov, L., Weiß, B., & Winkelmann, A. (2010). A model based approach for calculating the process driven business value of RFID investments. International Journal of Production Economics, 127(2), 358-371.

Beliën, J., Demeulemeester, E., de Bruecker, P., van den Bergh, J., & Cardoen, B. (2013). Integrated staffing and scheduling for an aircraft line maintenance problem. Computers & Operations Research, 40(4), 1023-1033.

Berman, R. C., & Tyyskä, V. (2011). A Critical Reflection on the Use of Translators/Interpreters in a Qualitative Cross-Language Research Project. International Journal of Qualitative Methods, 10(1), 178-190.

Best, E., & Weth, M. (2010). Process Excellence: Praxisleitfaden für erfolgreiches Prozessmanagement (4 ed.). Wiesbaden: Gabler.

Bezerra Barquet, A. P., Gouvea de Oliveira, M., Román Amigo, C., Pinheiro Cunha, V., & Rozenfeld, H. (2013). Employing the business model concept to support the adoption of product-service systems (PSS). Industrial Marketing Management, 42(5), 693-704.

Bickel, R. W. (2003). Improving Air Force Purchasing and Supply Management of Spare Parts. (Ph.D.), Frederick S. Pardee RAND Graduate School, Santa Monica, CA.

Bilbao-Osorio, B., Dutta, S., & Lanvin, B. (2014). The Global Information Technology Report 2014: Rewards and Risks of Big Data (pp. 1-369). Geneva: World Economic Forum and INSEAD.

Birman, K. P., & Glade, B. B. (1995). Reliability Through Consistency. IEEE Software, 12(3), 29-41.

Blumberg, D. F. (1999). Strategic examination of reverse logistics & repair service requirements, needs, market size, and opportunities. Journal of Business Logistics, 20(2), 141-159.

Brax, S. (2005). A manufacturer becoming service provider: challenges and a paradox. Managing Service Quality, 15(2), 142-155.

Brax, S. A., & Jonsson, K. (2009). Developing integrated solution offerings for remote diagnostics: A comparative case study of two manufacturers. International Journal of Operations & Production Management, 29(5), 539-560.

Brorson, L., Maidi, R., Stettler, J., & Vos, D. (2015). Mining Equipment: Quagmire or gold mine? (pp. 1-17). London: Barclays Equity Research.

Brunet, S., Devevey, J.-B., Pez, L., Veverka, R., & Li, K. (2015). Crouching miner, hidden dragon (pp. 1-95). London: Exane BNP Paribas.

Bryman, A., & Bell, E. (2011). Business research methods (3 ed.). Oxford, NY: Oxford University Press.

Butler, D., Fletcher, A., Rossouw, I., Pretorius, L., Learmonth, C., Ravi, E., & Sergievsky, V. (2014). UK Mining: Walkinig a tightrope (pp. 1-58). London: Barclays Equity Research.

Caggiano, K. E., Jackson, P. L., Muckstadt, J. A., & Rappold, J. A. (2007). Optimizing Service Parts Inventory in a Multiechelon, Multi-Item Supply Chain with Time-Based Customer Service-Level Agreements. Operations Research, 55(2), 303–318.

Candas, M. F., & Kutanoglu, E. (2007). Benefits of considering inventory in service parts logistics network design problems with time-based service constraints. IIE Transactions, 39(2), 159-176.

Candi, M., & Kahn, K. B. (2016). Functional, emotional, and social benefits of new B2B services. Industrial Marketing Management, 57, 177-184.

Carr, M. J., & Christer, A. H. (2003). Incorporating the potential for human error in maintenance models. Journal of the Operational Research Society, 54(12), 1249-1253.

Cavalcante, C. A. V., & de Almeida, A. T. (2007). A multi-criteria decision-aiding model using PROMETHEE III for preventive maintenance planning under uncertain conditions. Journal of Quality in Maintenance Engineering, 13(4), 385-397.

Cavalieri, S., Gaiardelli, P., & Ierace, S. (2007). Aligning strategic profiles with operational metrics in after-sales service. International Journal of Productivity and Performance Management, 56(5/6), 436-455.

Chae, B., Olson, D., & Sheu, C. (2014). The impact of supply chain analytics on operational performance: a resource-based view. International Journal of Production Research, 52(16), 4695-4710.

Chang, P.-L., & Lu, K.-H. (1994). Reducing inventory/sale monthly index of spare parts by quality control tools. Production and Inventory Management Journal, 35(4), 69-74.

Cheng, C.-Y., Barton, D., & Prabhu, V. (2010). The servicisation of the cutting tool supply chain. International Journal of Production Research, 48(1), 1-19.

Chidlow, A., Plakoyiannaki, E., & Welch, C. (2014). Translation in cross-language international business research: Beyond equivalence. Journal of International Business Studies, 45(5), 562-582.

Choi, T. Y., Dooley, K. J., & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: control versus emergence. Journal of Operations Management, 19, 351-366.

Choi, T. Y., & Krause, D. R. (2006). The supply base and its complexity: Implications for transaction costs, risks, responsiveness, and innovation. Journal of Operations Management, 24, 637-652.

Choy, K. L., Chow, H. K. H., Lee, W. B., & Chan, F. T. S. (2007). Development of performance measurement system in managing supplier relationship for maintenance logistics providers. Benchmarking: An International Journal, 14(3), 352-368.

Christopher, M. (2010). New directions in logistics. In Waters, D. (Ed.), Global Logistics: New Directions in Supply Chain Management (pp. 1-13). London: Kogan Page.

Coghlan, D. (2004). Action Research in the Academy: Why and Whither? Reflections on the Changing Nature of Research. Irish Journal of Management, 25(2), 1-10.

Cohen, M., Kamesam, P. V., Kleindorfer, P., Lee, H., & Tekerian, A. (1990). Optimizer: IBM's Multi-Echelon Inventory System for Managing Service Logistics. INTERFACES, 20(1), 65-82.

Cohen, M. A., Agrawal, N., & Agrawal, V. (2006). Winning in the Aftermarket. Harvard Business Review, 84(5), 129-138.

Cohen, M. A., Cull, C., Lee, H. L., & Willen, D. (2000). Saturn's Supply-Chain Innovation: High Value in After-Sales Service. Sloan Management Review, 41(3), 93-101.

Cohen, M. A., Zheng, Y.-S., & Agrawal, V. (1997). Service parts logistics: a benchmark analysis. IIE Transactions, 29(8), 627-639.

Cohen, M. A., Zheng, Y.-S., & Wang, Y. (1999). Identifying Opportunities for Improving Teradyne's Service-Parts Logistics System. INTERFACES, 29(4), 1-18.

Coyne, I. T. (1997). Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? Journal of Advanced Nursing, 26(3), 623-630.

Creswell, J. W., Hanson, W. E., Plano Clark, V. L., & Morales, A. (2007). Qualitative Research Designs: Selection and Implementation. The Counseling Psychologist, 35(2), 236-264.

Cronin Jr., J. J., & Taylor, S. A. (1992). Measuring Service Quality: A Reexamination and Extension. Journal of Marketing, 56(3), 55-68.

Cunliffe, A. L. (2008). Orientations to Social Constructionism: Relationally Responsive Social Constructionism and its Implications for Knowledge and Learning. Management Learning, 39(2), 123-139.

Davenport, T. H. (1993). Process Innovation: Reengineering Work Through Information Technology. Boston: Harvard Business Press.

Davies, M. (1995). Delivering the fastest growth. Director, 49, 75-77.

de Souza, R., Tan, A. W. K., Othman, H., & Garg, M. (2011). A proposed framework for managing service parts in automotive and aerospace industries. Benchmarking: An International Journal, 18(6), 769-782.

Debus, F. (2012). Picture of the Future: Spare Parts Logistics 2025. Presentation presented at the Spare Parts Logistics 2025 Focus Day: The Future of Spare Parts Logistics, Munich.

Dekker, R., Pinçe, Ç., Zuidwijk, R., & Jalil, M. N. (2013). On the use of installed base information for spare parts logistics: A review of ideas and industry practice. International Journal of Production Economics, 143(2), 536-545.

Della Porta, D., & Keating, M. (2008). How many approaches in the social sciences? An epistemological introduction. In Della Porta, D., & Keating, M. (Ed.), Approaches and Methodologies in the Social Sciences: A Pluralist Perspective (pp. 19-39). Cambridge: Cambridge University Press.

Ding, M. J., Kam, B. H., Zhang, J. Y., & Jie, F. (2015). Effects of human resource management practices on logistics and supply chain competencies: evidence from China logistics service market. International Journal of Production Research, 53(10), 2885-2903.

Dittrich, I. (2008). Ein Beitrag zur Optimierung der Informationslogistik im Ersatzteilwesen der Automobilindustrie. (Dr.-Ing.), Kaiserslautern University of Technology, Kaiserslautern.

Dobmeier, M. (2016). Understanding and Managing Service Productivity: A Literature Review. Journal of Business Market Management, 9(1), 518-540.

Dohi, T., Kaio, N., & Osaki, S. (1996). Optimal ordering policies with time-dependent delay structure. Journal of Quality in Maintenance Engineering, 2(1), 50-62.

Dölarslan, E. S. (2014). Assessing the effects of satisfaction and value on customer loyalty behaviors in service environments: High-speed railway in Turkey as a case study. Management Research Review, 37(8), 706-727.

Drohomeretski, E., Gouvea de Costa, S. E., Pinheiro de Lima, E., & da Rosa Garbuio, P. A. (2014). Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy. International Journal of Production Research, 52(3), 804-824.

Dombrowski, U., & Schulze, S. (2008). Lebenszyklusorientiertes Ersatzteilmanagement: Neue Herausforderungen durch innovationsstarke Bauteile in langlebigen Primärprodukten. In Nyhuis, P. (Ed.), Beiträge zu einer Theorie der Logistik (pp. 439-462). Berlin: Springer.

Durugbo, C. (2014). Strategic framework for industrial product-service co-design: findings from the microsystems industry. International Journal of Production Research, 52(10), 2881-2900.

Easterby-Smith, M., Thorpe, R., & Jackson, P. (2012). Management Research (4 ed.). London: SAGE.

Edwards, R., & Holland, J. (2013). What is Qualitative Interviewing? London: Bloomsbury.

Elder-Vass, D. (2012a). The Reality of Social Construction. Cambridge: Cambridge University Press.

Elder-Vass, D. (2012b). Towards a realist social constructionism. Sociologia, Problemas e Práticas, 70(1), 9-24.

Enarsson, L. (2006). Future Logistics Challenges. Copenhagen: Copenhagen Business School Press.

Ericsson, M. (2012). Trends in the mining and metals industry (pp. 1-16). London: The International Council on Mining and Metals.

Euler Hermes. (2013). Computer Hardware: Industry Outlook (pp. 1-6). Owings Mills, MD: Euler Hermes.

Evershed, J., & Roper, J. (2010). Teaching Information Technology 14+. Maidenhead: Open University Press.

EYGM Limited. (2014). Mining equipment overview (pp. 1-3). London: EYGM Limited.

Ferdows, K., & de Meyer, A. (1990). Lasting Improvements in Manufacturing Performance: In Search of a New Theory. Journal of Operations Management, 9(2), 168-184.

Flick, U. (2009). An Introduction to Qualitative Research (4 ed.). London: SAGE.

Focus Online. (2013). Ärger bei BMW: Werkstätten und Kunden warten Wochen auf Ersatzteile. Retrieved 12. July, 2013, from http://www.focus.de/auto/news/aerger-bei-bmw-werkstaetten-und-kunden-warten-wochen-auf-ersatzteile_aid_1037183.html

Folger, R., & Stein, C. (2017). Abduction 101: Reasoning processes to aid discovery. Human Reource Management Review, 27(2), 306-315.

Ford, H. (2007). My Life and Work. New York, NY: Cosimo.

Fortmann, K.-M., & Kallweit, A. (2000). Logistik. Stuttgart: Kohlhammer.

Fusch, P. I., & Ness, L. R. (2015). Are We There Yet? Data Saturation in Qualitative Research. The Qualitative Report, 20(9), 1408-1416.

Gaiardelli, P., Saccani, N., & Songini, L. (2007). Performance measurement of the after-sales service network: Evidence from the automotive industry. Computers in Industry, 58(7), 698-708.

Garikaparthi, M. (2014). Service Quality: A Key to Success and Customer Satisfaction. International Journal of Applied Services Marketing Perspectives, 3(3), 1138-1141.

Gáspár, A., & Szász, L. (2014). The impact of servitization on the manufacturer's business model and financial performance: A case study of a Romanian pharmaceutical company. Managerial Challenges of the Contemporary Society, 7(1), 108-114.

Gebauer, H. (2007). Extending the Service Business in China: Experience of Swiss Companies. Singapore Management Review, 29(1), 59-71.

Gebauer, H., Edvardsson, B., & Bjurko, M. (2010). The impact of service orientation in corporate culture on business performance in manufacturing companies. Journal of Service Management, 21(2), 237-259.

Gebauer, H., Fleisch, E., & Friedli, T. (2005). Overcoming the Service Paradox in Manufacturing Companies. European Management Journal, 23(1), 14-26.

Gebauer, H., Krempl, R., & Fleisch, E. (2008). Service development in traditional product manufacturing companies. European Journal of Innovation Management, 11(2), 219-240.

Gebauer, H., Krempl, R., Fleisch, E., & Friedli, T. (2008). Innovation of product-related services. Managing Service Quality, 18(4), 387-404.

Gebauer, H., Joncourt, S., & Saul, C. (2016). Services in product-oriented companies: past, present, and future. Universia Business Review, 32-53.

Gebauer, H., Pütz, F., Fischer, T., & Fleisch, E. (2009). Service Orientation of Organizational Structures. Journal of Relationship Marketing, 8(2), 103-126.

Gebauer, H., Ren, G.-J., Valtakoski, A., & Reynoso, J. (2012). Service-driven manufacturing: Provision, evolution and financial impact of services in industrial firm. Journal of Service Management, 23(1), 120-136.

Genchev, S. E. (2007). Assessing reverse logistics complexity: Conceptual model, scale development, and a case study. (Ph.D.), University of Oklahoma, Norman, OK.

Gershon, M. (2010). Choosing Which Process Improvement Methodology to Implement. Journal of Applied Business and Economics, 10(5), 61-69.

Ghotbabadi, A. R., Feiz, S. & Baharun, R. (2015). Service Quality Measurements: A Review International Journal of Academic Research in Business and Social Sciences, 5(2), 267-286.

Giri, B. C., Dohi, T., & Kaio, N. (2006). Discrete-time spare ordering policy with randomized lead times and discounting. International Transactions in Operational Research, 13(6), 561-576.

Glaser, B. G., & Strauss, A. L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. New Brunswick, NJ: AldineTransaction.

Gläser, J., & Laudel, G. (2010). Experteninterviews und qualitative Inhaltsanalyse (4 ed.). Wiesbaden: VS Verlag für Sozialwissenschaften.

Gleißner, H., & Möller, K. (2011). Case Studies in Logistics. Wiesbaden: Gabler.

Goddard, J., & Pierre, A. (2016). Strategic Thinking: How CEOs Can Manage Strategic Tensions. Harvard Business Review, December Issue, 2-5.

Godoy, D. R., Pascual, R., & Knights, P. (2013). Critical spare parts ordering decisions using conditional reliability and stochastic lead time. Reliability Engineering and System Safety, 119, 199-206.

Goel, A., & Meisel, F. (2013). Workforce routing and scheduling for electricity network maintenance with downtime minimization. European Journal of Operational Research, 231(1), 210-228.

Golmakani, H. R., & Fattahipour, F. (2011). Optimal replacement policy and inspection interval for condition-based maintenance. International Journal of Production Research, 49(17), 5153-5167.

Gopal, P. R. C., & Thakkar, J. (2012). A review on supply chain performance measures and metrics: 2000-2011. International Journal of Productivity and Performance Management, 61(5), 518-547.

Gravelle, J., Winzenried, S., & Hodge, A. (2014). Mine 2014: Realigning expectations (pp. 1-52). London: PWC.

Guba, E. G., & Lincoln, Y. S. (1994). Competing Paradigms in Qualitative Research. In Denzin, N. K., & Lincoln, Y. S. (Ed.), Handbook of Qualitative Research (pp. 105-117). Thousand Oaks, CA: SAGE.

Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A framework for supply chain performance measurement. International Journal of Production Economics, 87(3), 333-347.

Günthner, W. A. (2008). Ereignisorientierte Logistik: Ein neuer Ansatz zur Steuerung von Logistiksystemen. In Nyhuis, P. (Ed.), Beiträge zu einer Theorie der Logistik (pp. 373-390). Berlin: Springer.

Guo, C., & Wang, Y. (2015). How manufacturer market orientation influences B2B customer satisfaction and retention: empirical investigation of the three market orientation components. Journal of Business & Industrial Marketing, 30(2), 182-193.

Guo, C., Wang, Y. J., & Metcalf, A. (2014). How to calibrate conventional market-oriented organizational culture in 21st century production-centered firms? A customer relationship perspective. International Journal of Production Economics, 156, 235-245.

Hagmann, M., Gibson, C., Zimmermann, T., & Chand, D. (2015). Elevators: Life after the China boom (pp. 1-32). London: HSBC Global Research.

Hammer, M., & Champy, J. (2006). Reengineering the Corporation: A Manifesto for Business Revolution. New York, NY: HarperCollins.

Hariharan, G., Chen, W., Park, J. J., & Rajwanshi, V. (2015). PC/Tablet forecast (pp. 1-14). New York, NY: J. P. Morgan Asia Pacific Equity Research.

Haugen, D. L., & Hill, A. V. (1999). Scheduling to improve field service quality. Decision Sciences, 30(3), 783-804.

Hayes, J., & Dredge, F. (1998). Managing Customer Service. Aldershot: Gower.

Hays, J. M., & Hill, A. V. (2001). A preliminary investigation of the relationships between employee motivation/vision, service learning, and perceived service quality. Journal of Operations Management, 19(3), 335-349.

Hays, J. M., & Hill, A. V. (2006). An Extended Longitudinal Study of the Effects of a Service Guarantee. Production and Operations Management, 15(1), 117-131.

Heinemann, E. (2010). T-Shaped Professional: Die Vorteile von Spezialist und Generalist vereint. Retrieved 09. August, 2014, from http://www.business-wissen.de/artikel/t-shaped-professional-die-vorteile-von-spezialist-und-generalist-vereint/

Henderson, N. R. (2010). Crafting Careful Qualitative Questions: Fruitful discussions start with powerful questions. Marketing Research, 22(1), 29-30.

Hodkinson, P., & Hodkinson, H. (2001). The Strengths and Limitations of Case Study Research. Paper presented at the Learning and Skills Development Agency Conference: Making an Impact on Policy and Practice, Cambridge.

Hölbling, K., Engelmann, J., & Nedelchev, A. (2009). Getting After-Sales Service Right: The Competitive Edge in Telecom and Consumer Electronics (pp. 1-4). New York, NY: Booz & Co.

Hopwood, P., Lane, A., Demidow, N., Hughes, C. D., Ives, G., & Quinlin, D. (2015). Tracking the trends 2015: The top 10 issues mining companies will face this year (pp. 1-47). New York, NY: Deloitte.

Huiskonen, J. (2001). Maintenance spare parts logistics: Special characteristics and strategic choices. International Journal of Production Economics, 71(1-3), 125-133.

Jahns, C., Darkow, I. L., & da Mota Pedrosa, A. (2007). Customer Integration in the New Service Development Process: A Case Study Approach in the Logistics Service Industry. In Blecker, T., Kersten, W., & Herstatt, C. (Ed.), Key Factors for Successful Logistics: Services, Transportation Concepts, IT and Management Tools (pp. 3-16). Berlin: Erich Schmidt.

Jalil, M. N. (2011). Customer Information Driven After Sales Service Management: Lessons from Spare Parts Logistics. (Ph.D.), Erasmus University, Rotterdam.

Jalil, M. N., Zuidwijk, R. A., Fleischmann, M., & van Nunen, J. A. E. E. (2011). Spare parts logistics and installed base information. Journal of the Operational Research Society, 62(3), 422-457.

Järvensivu, T., & Törnroos, J.-Å. (2010). Case study research with moderate constructionism: Conceptualization and practical illustration. Industrial Marketing Management, 39(1), 100-108.

Jarzemsky, M. (2011). Printer Firms in Transition. New York, NY: The Wall Street Journal.

Jin, T., & Tian, Y. (2012). Optimizing reliability and service parts logistics for a time-varying installed base. European Journal of Operational Research, 218(1), 152-162.

Johnson, W. B. (2013). KONE in China. Presentation presented at the Morgan Stanley China Summit, Beijing.

Jovanovic, M., Engwall, M., & Jerbrant, A. (2016). Matching Service Offerings and Product Operations: A Key to Servitization Success. Research-Technology Management, 59(3), 29-36.

Kaiser, S., Kozica, A., Swart, J., & Werr, A. (2015). Human Resource Management in Professional Servie Firms: Learning from a framework for research and practice. German Journal of Research in Human Resource Management, 29(2), 77-101.

Kam, B. H. (2010). Does human resource management contribute to the development of logstics and supply chain capabilities? An empirical study of logistics service providers in China. Research and Practice in Human Resource Management, 18(2), 15-34.

Kans, M. (2009). The advancement of maintenance information technology: A literature review. Journal of Quality in Maintenance Engineering, 15(1), 5-16.

Karagiannaki, A., Papakiriakopoulos, D., & Bardaki, C. (2011). Warehouse contextual factors affecting the impact of RFID. Industrial Management & Data Systems, 111(5), 714-734.

Karsten, F., Slikker, M., & van Houtum, G.-J. (2012). Inventory Pooling Games for Expensive, Low-Demand Spare Parts. Naval Research Logistics, 59(5), 311-324.

Kastalli, I. V., & van Looy, B. (2013). Servitization: Disentangling the impact of service business model innovation on manufacturing firm performance. Journal of Operations Management, 31(4), 169-180.

Kilduff, M., Mehra, A., & Dunn, M. B. (2011). From Blue Sky Research to Problem Solving: A Philosophy of Science Theory of New Knowledge Production. Academy of Management Review, 36(2), 297-317.

Kinnunen, R.-E., & Turunen, T. (2012). Identifying Servitization Capabilities of Manufacturers: A Conceptual Model. Journal of Applied Management and Entrepreneurship, 17(3), 55-78.

Kleijnen, J. P. C., & Smits, M. T. (2003). Performance metrics in supply chain management. Journal of the Operational Research Society, 54(5), 507-514.

Klug, F. (2010). Logistikmanagement in der Automobilindustrie: Grundlagen der Logistik im Automobilbau. Heidelberg: Springer.

Koçağa, Y. L., & Şen, A. (2007). Spare parts inventory management with demand lead times and rationing. IIE Transactions, 39(9), 879-898.

Koncept Analytics. (2010). Global Escalator & Elevator Market Report: 2010 Edition (pp. 1-31). New Delhi: Koncept Analytics.

Köpfli, P., & Amstutz, K. (2008). Optimale Ersatzteil-Logistik für ein effizientes Servicegeschäft. interview Magazin, 46-48.

Kraemer, K. L., & Dedrick, J. (n.d.). Dell Computer: Organization of a Global Production Network (pp. 1-17). Irvine, CA: Center for Research on Information Technology and Organizations.

Kranenburg, A. A., & van Houtum, G. J. (2007). Effect of commonality on spare parts provisioning costs for capital goods. International Journal of Production Economics, 108(1-2), 221-227.

Lapré, M. A., & Scudder, G. D. (2004). Performance Improvement Paths in the U.S. Airline Industry: Linking Trade-offs to Asset Frontiers. Production and Operations Management, 13(2), 123-134.

Laws, K., & McLeod, R. (2004). Case study and grounded theory: Sharing some alternative qualitative research methodologies with systems professionals. Paper presented at the 22nd International Conference of the Systems Dynamics Society, Oxford.

Lenius, P. (1998). Increasing warehouse efficiency. Supply House Times, 41, 93-100.

Li, S., Godon, D., & Visich, J. K. (2010). An exploratory study of RFID implementation in the supply chain. Management Research Review, 33(10), 1005-1015.

Limam Mansar, S., & Reijers, H. A. (2007). Best practices in business process redesign: use and impact. Business Process Management Journal, 13(2), 193-213.

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic Inquiry. Newbury Park, CA: SAGE.

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2011). Paradigmatic Controversies, Contradictions, and Emerging Confluences, Revisited. In Denzin, N. K., & Lincoln, Y. S. (Ed.), The SAGE Handbook of Qualitative Research (4 ed., pp. 97-128). Thousand Oaks, CA: SAGE.

Liu, Y., & Liang, L. (2015). Evaluating and developing resource-based operations strategy for competitive advantage: an exploratory study of Finnish high-tech manufacturing industries International Journal of Production Research, 53(4), 1019-1037.

Lofsten, H. (1999). Management of industrial maintenance - economic evaluation of maintenance policies. International Journal of Operations & Production Management, 19(7), 716-737.

Lunau, S., Meran, R., John, A., Staudter, C., & Roenpage, O. (2013). Six Sigma +Lean Toolset: Mindset zur erfolgreichen Umsetzung von Verbesserungsprojekten (4 ed.). Berlin: Springer Gabler.

Mak, B. L., & Sockel, H. (2001). A confirmatory factor analysis of IS employee motivation and retention. Information & Management, 38(5), 265-276.

Martin, M. J. (2016). Customers' Determination of Service Quality and Satisfaction in a Return/Repair Process: A Quantitative Study. International Academy of Marketing Studies Journal, 20(1), 36-52.

Marshall, C., & Rossman, G. B. (2011). Designing Qualitative Research (5 ed.). Thousand Oaks, CA: SAGE.

Mason, M. (2010). Sample Size and Saturation in PhD Studies Using Qualitative Interviews. Forum: Qualitative Social Research, 11(3), Article 8.

Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information Technology and Sustained Competitive Advantage: A Resource-Based Analysis. MIS Quarterly, 19(4), 487-505.

Mathieu, V. (2001a). Product services: from a service supporting the product to a service supporting the client. The Journal of Business & Industrial Marketing, 16(1), 39-58.

Mathieu, V. (2001b). Service strategies within the manufacturing sector: Benefits, costs and partnership. International Journal of Service Industry Management, 12(5), 451-475.

Mellat-Parast, M., Golmohammadi, D., McFadden, K. L., & Miller, J. W. (2015). Linking business strategy to service failures and financial performance: Empirical evidence from the U.S. domestic airline industry. Journal of Operations Management, 38, 14-24.

Merriam, S. B. (2009). Qualitative Research: A Guide to Design and Implementation (2 ed.). San Francisco, CA: Jossey-Bass.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative Data Analysis: A Methods Sourcebook (3 ed.). Thousand Oaks, CA: SAGE.

Milliken, A. L. (2001). Key ingredients of successful performance metrics in the supply chain. Journal of Business Forecasting Methods & Systems, 20(2), 23-28.

Mingers, J. (2012). Viewpoints: Abduction: the missing link between deduction and induction. A comment on Ormerod's 'rational inference: deductive, inductive and probabilistic thinking'. Journal of the Operational Research Society, 63, 860-861.

Mir, R., & Watson, A. (2000). Strategic Management and the Philosophy of Science: The Case for a Constructivist Methodology. Strategic Management Journal, 21(9), 941-953.

Mirzahosseinian, H., & Piplani, R. (2013). Impact of Operational Systems on Suppliers' Response Under Performance-based Contracts. Procedia Computer Science, 16, 639-647.

Mkansi, M., & Acheampong, E. A. (2012). Research Philosophy Debates and Classifications: Students' Dilemma. The Electronic Journal of Business Research Methods, 10(2), 132-140.

Mollenkopf, D. A., & Closs, D. J. (2005). The Hidden Value in REVERSE LOGISTICS. Supply Chain Management Review, 9, 34-43.

Molloy, J. C., & Barney, J. B. (2015). Who Captures the Value Created with Human Capital? A Market-Based View. Academy of Management Perspectives, 29(3), 209-325.

Mont, O. (2002). Clarifying the Concept of Product-Service System. Journal of Cleaner Production, 10(3), 237-245.

Moore, C. (1999). Best Practices: Eureka! Xerox discovers way to grow community knowledge. And customer satisfaction. Retrieved 12. July, 2013, from http://www.kmworld.com/Articles/Editorial/Features/Best-Practices-Eureka!-Xerox-discovers-way-to-grow-community-knowledge.-.-And-customer-satisfaction-9140.aspx

Moorman, R. W. (2007). RFID: Ready For Industry Doubters? Air Transport World, 75-78.

Moser, R., Kuklinski, C. P. J. W., & Weidmann, M. (2014). The impact of institutions on the resources of foreign companies: the case of third party logistics service providers in Russia. Journal for East European Management Studies, 19(3), 305-326.

Mousavizadeh, N., Haynes, L., Russell, D., Newall, P., van der Wath, K., Lavan, T., ..., & van Rhyn, J. (2013). Mining Market Review (pp. 1-76). London: Willis Limited.

Muchiri, P. N., Pintelon, L., Martin, H., & de Meyer, A.-M. (2010). Empirical analysis of maintenance performance measurement in Belgian industries. International Journal of Production Research, 48(20), 5905-5924.

Muckstadt, J. A. (1973). A Model for a Multi-Item, Mutli-Echelon, Multi-Indenture Inventory System. Management Science, 20(4), 472-481.

Muckstadt, J. A., & Thomas, L. J. (1980). Are Multi-Echelon Inventory Methods Worth Implementing in Systems with Low-Demand-Rate Items? Management Science, 26(5), 483-494.

Napolitano, M. (2003). Low cost ways to boost warehouse efficiency. Logistics Management, 42, 59-64.

Narver, J. C., & Slater, S. F. (1990). The Effect of a Market Orientation on Business Profitability. Journal of Marketing, 54(4), 20-35.

Newman, B. (2005). Twelve best practices for managing overnight delivery. Office Solutions, 22, 24-27.

Ngai, E. W. T., Cheung, B. K. S., Lam, S. S., & Ng, C. T. (2014). RFID value in aircraft parts supply chains: A case study. International Journal of Production Economics, 147(B), 330-339.

Ngai, E. W. T., Moon, K. K. L., Riggins, F. J., & Yi, C. Y. (2008). RFID research: An academic literature review (1995–2005) and future research directions. International Journal of Production Economics, 112(2), 510-520.

Nikolopoulos, K., Metaxiotis, K., Lekatis, N., & Assimakopoulos, V. (2003). Integrating industrial maintenance strategy into ERP. Industrial Management & Data Systems, 103(3/4), 184-191.

Oke, S. A., Ayomoh, M. K. O., & Oyedokun, I. O. (2007). An approach to measuring the quality of maintenance performance. IMA Journal of Management Mathematics, 18, 17-32.

Oliva, R., Gebauer, H., & Brann, J. M. (2012). Separate or Integrate? Assessing the Impact of Separation Between Product and Service Business on Service Performance in Product Manufacturing Firms. Journal of Business-to-Business Marketing, 19(4), 309-334.

Oliva, R., & Kallenberg, R. (2003). Managing the transition from products to services. International Journal of Service Industry Management, 14(2), 160-172.

Öner, K. B. (2010). Optimal Reliability and Upgrading Decisions for Capital Goods. (Ph.D.), Eindhoven University of Technology, Eindhoven.

Othman, M., Bhuiyan, N., & Gouw, G. J. (2012). Integrating workers' differences into workforce planning. Computers & Industrial Engineering, 63(4), 1096-1106.

Outhwaite, W. (2007). Cases, Comparisons, and Theory: Introduction. In Outhwaite, W., & Turner, S. P. (Ed.), The SAGE Handbook of Social Science Methodology (pp. 53-54). London: SAGE.

Padgett, D. K. (2017). Qualitative Methods in Social Work Research (3 ed.). Los Angeles, CA: SAGE.

Paiola, M., Saccani, N., Perona, M., & Gebauer, H. (2013). Moving from products to solutions: Strategic approaches for developing capabilities. European Management Journal, 31(4), 390-409.

Panizzolo, R. (2008). A methodology to measure the value of services provided to customers in manufacturing firm. Measuring Business Excellence, 12(3), 3-15.

Pannucci, C. J., & Wilkins, E. G. (2010). Identifying and Avoiding Bias in Research. Plastic and Reconstructive Surgery, 126(2), 619-625.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality. Journal of Retailing, 64(1), 12-40.

Patton, M. Q. (2002). Qualitative Research Evaluation Methods (3 ed.). Thousand Oaks, CA: SAGE.

Petersen, C. G. (1999). The impact of routing and storage policies on warehouse efficiency. International Journal of Operations & Production Management, 19(10), 1053-1064.

Petticrew, M. (2001). Systematic reviews from astronomy to zoology: myths and misconceptions. British Medical Journal, 322(7278), 98-101.

Pfohl, H.-C. (2004). Logistikmanagement: Konzeption und Funktionen (2 ed.). Berlin: Springer.

Pfohl, H.-C., & Trumpheller, M. (2005). Stellenwert der Ersatzteillogistik in der Luftfahrt. thema FORSCHUNG, 3, 40-44.

Piplani, R., & Saraswat, A. (2012). Robust optimisation approach to the design of service networks for reverse logistics. International Journal of Production Research, 50(5), 1424-1437.

Ployhart, R. E., van Iddekinge, C. H., & Mackenzie Jr., W. I. (2011). Acquiring and Developing Human Capital in Service Contexts: The Interconnectedness of Human Capital Resources. Academy of Management Journal, 54(2), 353-368.

Politis, Y., Giovanis, A., & Binioris, S. (2014). Logistics service quality and its effects on customer satisfaction in the manufacturing companies' supply chains: Empirical evidence from Greece. Journal of Modelling in Management, 9(2), 215-237.

Porter, C. (2012). The Hawthorne effect today. Industrial Management, 54(3), 10-15.

Porter, M. E. (1985). Competitive Advantage: Creating and Sustaining Superior Performance. New York, NY: The Free Press.

Psomas, E. L., Fotopoulos, C. V., & Kafetzopoulos, D. P. (2011). Core process management practices, quality tools and quality improvement in ISO 9001 certified manufacturing companies. Business Process Management Journal, 17(3), 437-460.

Quinn, J. B., Doorley, T. L., & Paquette, P. C. (1990). Technology in Services: Rethinking Strategic Focus. Sloan Management Review, 31(2), 79-87.

Quintana, R., & Ortiz, J. G. (2002). Increasing the effectiveness and cost-efficiency of corrective maintenance using relay-type assignment. Journal of Quality in Maintenance Engineering, 8(1), 40-61.

Raddats, C., & Kowalkowski, C. (2014). A Reconceptualization of Manufacturers' Service Strategies. Journal of Business-to-Business Marketing, 21, 19-34.

Raja, J. Z., Green, S. D., & Leiringer, R. (2010). Concurrent and disconnected change programmes: strategies in support of servitization and the implementation of business partnering. Human Resource Management, 20(3), 258-276.

Ramanathan, R., Ramanathan, U., & Ko, L. W. L. (2014). Adoption of RFID technologies in UK logistics: Moderating roles of size, barcode experience and government support. Expert Systems with Applications, 41(1), 230-236.

Ray, G., Barney, J. B., & Muhanna, W. A. (2004). Capabilities, Business Process, and Competitive Advantage: Choosing the Dependent Variable in Empirical Tests of the Resource-Based View. Strategic Management Journal, 25, 23-37.

Reason, P., & Bradbury, H. (2006). Introduction: Inquiry and Participation in Search of a World Worthy of Human Aspiration. In Reason, P., & Bradbury, H. (Ed.), Handbook of Action Research (2 ed., pp. 1-14). London: SAGE.

Refai, D., Klapper, R. G., & Thompson, J. (2015). A holistic social constructionist perspective to enterprise education. International Journal of Entrepreneurial Behavior & Research, 21(3), 316-337.

Regmi, K., Naidoo, J., & Pilkington, P. (2010). Understanding the Processes of Translation and Transliteration in Qualitative Research. International Journal of Qualitative Methods, 9(1), 16-26.

Regtmeier, J. (2012). Wartungsmanagement mittels RFID optimieren: Durch den Einsatz von RFID-Technologie lassen sich Zeit- und Geldersparnisse realisieren. Einblick in AutoID/RFID, 92-93.

Rennemo, Ø., & Åsvoll, H. (2014). Abduction, Deduction and Induction as Concepts for Understanding Entrepreneurial Opportunities, a Meta-Perspective Based on Three Views of the Market Process. Academy of Entrepreneurship Journal, 20(2), 164-188.

Rivera, J., & Goasduff, L. (2015). Gartner Says Worldwide IT Spending to Decline 5.5 Percent in 2015. Retrieved 15. August, 2015, from http://www.gartner.com/newsroom/id/3084817

Rizzo, K. (2008). Total productive maintenance. American Printer, 125(9), 16-20.

Roland Berger Strategy Consultants. (2010). From product to service: How service orientation can generate long-term growth in the telco industry (pp. 1-19). Munich: Roland Berger Strategy Consultants.

Romeijnders, W., Teunter, R., & van Jaarsveld, W. (2012). A two-step method for forecasting spare parts demand using information on component repairs. European Journal of Operational Research, 220(2), 386-393.

Santos, F. C. A. (2000). Integration of human resource management and competitive priorities of manufacturing strategy. International Journal of Operations & Production Management, 20(5), 610-628.

Samet, S., Chelbi, A., & ben Hmida, F. (2010). Optimal availability of failure-prone systems under imperfect maintenance actions. Journal of Quality in Maintenance Engineering, 16(4), 395-412.

Sarniak, R. (2015). 9 types of research bias and how to avoid them. Retrieved 15. April, 2017, from https://www.quirks.com/articles/9-types-of-research-bias-and-how-to-avoid-them

Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods for business students (5 ed.). Essex: Pearson Education.

SCDigest Editorial Staff. (2007). Role of Service Parts Logistics in High Tech Continues to Grow, Report Says, with Big Impact on Companies and Logistics Service Providers: New Report from Transport Intelligence Looks at European Market, but the Insight is also Beneficial for North American Companies. Retrieved 12. July, 2013, from http://scdigest.com/assets/newsViews/07-03-08-4.cfm

Schake, T. (2000). Logistikkonzeptionen: Band 1: Theoretische Grundlagen und Modellierung. Bern: TCS.

Schneider, J. A. (n.d.). IRB Boards and Qualitative Research: Bonus Handouts #4 - Ethics, Confidentiality and Informed Consent. Bonita Springs, FL: Principal Investigators Association.

Schroeder, R. G., Shah, R., & Peng, D. X. (2011). The cumulative capability ‘sand cone’ model revisited: a new perspective for manufacturing strategy. International Journal of Production Research, 49(16), 4879-4901.

Schulte, G. (2001). Material- und Logistikmanagement (2 ed.). Munich: Oldenbourg.

Schultz, C. R. (2004). Spare parts inventory and cycle time reduction. International Journal of Production Research, 42(4), 759-776.

Schuh, G., Stich, V., & Wienholdt, H. (2013). Ersatzteillogistik. In Schuh, G., & Stich, V. (Ed.), Logistikmanagement (pp. 165-208). Berlin: Springer.

Scudder, G. D. (1984). Priority Scheduling and Spares Stocking Policies for a Repair Shop: The Multiple Failure Case. Management Science, 30(6), 739-749.

Shanahan, J. (2002). The need for speed. Logistics Management, 42, 49-52.

Shanmugam, A., & Paul Robert, T. (2015). Ranking of aircraft maintenance organization based on human factor performance. Computers & Industrial Engineering, 88(C), 410-416.

Shehata, R. (2014). ThyssenKrupp Industrial Solutions - Resource Technologies: Innovative Customer Solutions. ThyssenKrupp Capital Market Day (pp. 1-13). Essen: ThyssenKrupp.

Sherbrooke, C. C. (1968). METRIC: A Multi-Echelon Technique for Recoverable Item Control. Operations Research, 16(1), 122-141.

Sherbrooke, C. C. (1971). An Evaluator for the Number of Operationally Ready Aircraft in a Multilevel Supply System. Operations Research, 19(3), 618-635.

Sherbrooke, C. C. (1986). VARI-METRIC: Improved Approximations for Multi-Indenture, Multi-Echelon Availability Models. Operations Research, 34(2), 311-319.

Singer, T. (2002). ERP solutions: Are they right for maintenance management? Plant Engineering, 56, 34-36.

Skinner, W. (1969). Manufacturing: Missing Link in Corporate Strategy. Harvard Business Review, 47(3), 136-145.

Slack, N., Brandon-Jones, A., & Johnston, R. (2014). Operations Management (7 ed.). Upper Saddle River, NJ: Prentice Hall.

Slack, N., Chambers, S., Johnston, R., & Betts, A. (2009). Operations and Process Management (2 ed.). Essex: Pearson Education.

Sleptchenko, A., van der Heijden, M. C., & van Harten, A. (2003). Trade-off between inventory and repair capacity in spare part networks. Journal of the Operational Research Society, 54(3), 263-272.

Smith, L., Maull, R., & Ng, I. C. L. (2014). Servitization and operations management: a service dominant-logic approach. International Journal of Operations & Production Management, 34(2), 242-269.

Ståhl, J. E., Gabrielson, P., Andersson, C., & Jönsson, M. (2012). Dynamic manufacturing costs: Describing the dynamic behavior of downtimes from a cost perspective. CIRP Journal of Manufacturing Science and Technology, 5(4), 284-295.

Stake, R. (1995). The art of case study research. Thousand Oaks, CA: SAGE.

Stalk Jr., G. (1988). Time: The Next Source of Competitive Advantage. In Montgomery, C. A., & Porter, M. E. (Ed.), Strategy: Seeking and Securing Competitive Advantage (pp. 39-60). Boston: Harvard Business Review.

Stapf, R. (2013). Spare Parts Rendezvous (pp. 1-3). Tokyo: German Chamber of Commerce and Industry in Japan.

Statista. (2015a). Global elevator and escalator market size in 2012 and 2017 (in billion U.S. dollars). Retrieved 08. August, 2015, from http://www.statista.com/statistics/261866/world-wide-sales-of-elevators-and-escalators/

Statista. (2015b). Leading companies worldwide in the area of elevators and escalators in 2014, based on revenue (in billion U.S. dollars). Retrieved 08. August, 2015, from http://www.statista.com/statistics/281179/leading-companies-in-the-area-of-elevators-and-escalators-by-revenue/

Statista. (2015c). Statistics and facts on mining, metals and minerals. Retrieved 09. August, 2015, from http://www.statista.com/markets/410/topic/954/mining-metals-minerals/

Statista. (2015d). Worldwide production printer market shipments value from 2013 to 2015, by quarter (in million U.S. dollars). Retrieved 14. November, 2015, from http://www.statista.com/statistics/410990/production-printer-market-revenue-worldwide/

Statista. (2016). Forecast growth of information technology (IT) spending worldwide in 2015 and 2016, by segment. Retrieved 25. March, 2016, from http://www.statista.com/statistics/440821/it-spending-growth-worldwide-by-segment/

Strähle, O., Füllemann, M., & Bendig, O. (2012). Service now! Time to wake up the sleeping giant: How service can boost long-term growth with attractive returns in industrial goods businesses (pp. 1-36). Munich: Bain & Company.

Sun, Y., Chiu, D. K. W., Gong, B., Meng, X., & Zhang, P. (2012). Scheduling mobile collaborating workforce for multiple urgent events. Journal of Network and Computer Applications, 35(1), 156-163.

Syntetos, A. A., Babai, M. Z., & Altay, N. (2012). On the demand distributions of spare parts. International Journal of Production Research, 50(8), 2101-2117.

Syntetos, A. A., Keyes, M., & Babai, M. Z. (2009). Demand categorisation in a European spare parts logistics network. International Journal of Operations & Production Management, 29(3), 292-316.

Szász, L., & Demeter, Z. (2013). Improving Operations Based on Competitive Priority Mapping: A Case Study in the Plastics Industry. Managerial Challenges of the Contemporary Society(6), 135-142.

Takala, K., & Virén, M. (2007). Impact of ATMS on the Use of Cash. Communications & Strategies, 66(2), 47-61.

Temple, B., & Edwards, R. (2002). Interpreters/Translators and Cross-Language Research: Reflexivity and Border Crossings. International Journal of Qualitative Methods, 1(2), Article 1.

Temple, B., & Young, A. (2004). Qualitative research and translation dilemmas. Qualitative Research, 4(2), 161-178.

The Economist. (2013). Top floor, please: Things are looking up for liftmakers. Retrieved 26. July, 2015, from http://www.economist.com/news/business/21573568-things-are-looking-up-liftmakers-top-floorplease

The Mining Association of Canada. (2014). Facts & Figures of the Canadian Mining Industry 2014 (pp. 1-111). Ottawa: The Mining Association of Canada.

The University of Gloucestershire. (2008). Research Ethics: A Handbook of Principles and Procedures. Retrieved 15. May, 2015, from http://insight.glos.ac.uk/ResearchDevelopment/Documents/Research%20Ethics%20Handbook%20final%20Nov%2010.pdf

Thompson, G. M., & Goodale, J. C. (2006). Variable employee productivity in workforce scheduling. European Journal of Operational Research, 170(2), 376-390.

ThyssenKrupp. (2015). ThyssenKrupp Equity Story: Elevator Technology (pp 1-37). Essen: ThyssenKrupp.

Tiemessen, H. G. H., & van Houtum, G. J. (2013). Reducing costs of repairable inventory supply systems via dynamic scheduling. International Journal of Production Economics, 143(2), 478-488.

Tinnilä, M. (1995). Strategic perspective to business process redesign. Management Decision, 33(3), 25-34.

Tiwari, R. (2015). Global and Chinese Elevator Market (Manufacturing & Development) Research Reports. Retrieved 26. July, 2015, from http://www.wallstreet-online.de/nachricht/7302107-global-and-chinese-elevator-market-manufacturing-development-research-reports

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. British Journal of Management, 14(3), 207-222.

Tsang, A. H. C., Jardine, A. K. S., & Kolodny, H. (1999). Measuring maintenance performance: a holistic approach. International Journal of Operations & Production Management, 19(7), 691-715.

Tukker, A. (2004). Eight Types of Product-Service System: Eight Ways to Sustainability? Experiences from Suspronet. Business Strategy and the Environment, 13(4), 246-260.

van der Heijden, M. C., Alvarez, E. M., & Schutten, J. M. J. (2013). Inventory reduction in spare part networks by selective throughput time reduction. International Journal of Production Economics, 143(2), 509-517.

van Gigch, J. P. (1965). Application of Critical-Path Analysis and Manpower Levelling to Maintenance Planning. CORS Journal, 3(2), 81-89.

van Kooten, J. P. J., & Tan, T. (2009). The final order problem for repairable spare parts under condemnation. Journal of the Operational Research Society, 60(10), 1449-1461.

Vandermerwe, S., & Rada, J. (1988). Servitization of Business: Adding Value by Adding Services. European Management Journal, 6(4), 314-324.

Verrijdt, J. H. C. M. (1997). Design and Control of Service Part Distribution Systems. (Ph.D.), Eindhoven University of Technology, Eindhoven.

Verschuren, P. J. M. (2003). Case study as a research strategy: some ambiguities and opportunities. International Journal of Social Research Methodology, 6(2), 121-139.

Viles, E., Puente, D., Alvarez, M. J., & Alonso, F. (2007). Improving the corrective maintenance of an electronic system for trains. Journal of Quality in Maintenance Engineering, 13(1), 75-87.

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. International Journal of Operations & Production Management, 22(2), 195-219.

Wagner, S. M., Jönke, R., & Eisingerich, A. B. (2012). A Strategic Framework for Spare Parts Logistics. California Management Review, 54(4), 69-92.

Wang, C., Li, B., Daneshmand, M., Sohraby, K., & Jana, R. (2011). On Object Identification Reliability Using RFID. Mobile Networks and Applications, 16(1), 71-80.

Wang, P. P., Ming, X. G., Li, D., Kong, F. B., Wang, L., & Wu, Z. Y. (2011). Status review and research strategies on product-service systems. International Journal of Production Research, 49(22), 6863-6883.

Weissenberger-Eibl, M. A., & Biege, S. (2010). Design for Industrial Product-Services Combinations: A Literature Review. Journal of Applied Management and Entrepreneurship, 15(3), 34-49.

Wellington, P. (2010). Effective Customer Care: Understand needs, Improve service, Build relationships. London: Kogan Page.

Whitaker, J., Mithas, S., & Krishnan, M. S. (2007). A Field Study of RFID Deployment and Return Expectations. Production and Operations Management, 16(5), 599-612.

Wise, R., & Baumgartner, P. (1999). Go Downstream: The New Profit Imperative in Manufacturing. Harvard Business Review, 77(5), 133-141.

Wisner, J. D., & Stanley, L. L. (2008). Process Management: Creating Value Along the Supply Chain: Text & Cases. Mason, OH: Thomson Higher Education.

Wong, H., van Houtum, G. J., Cattrysse, D., & van Oudheusden, D. (2005). Simple, efficient heuristics for multi-item multi-location spare parts systems with lateral transshipments and waiting time constraints. Journal of the Operational Research Society, 56(12), 1419-1430.

Wong, H., Kranenburg, B., van Houtum, G.-J., & Cattrysse, D. (2007). Efficient heuristics for two-echelon spare parts inventory systems with an aggregate mean waiting time constraint per local warehouse. OR Spectrum, 29(4), 699-722.

Woo, S. E., O'Boyle, E. H., & Spector, P. E. (2017). Best practices in developing, conducting, and evaluating inductive research. Human Reource Management Review, 27(2), 255-264.

Wright, P. M., McMahan, G. C., & McWilliams, A. (1994). Human resources and sustained competitive advantage: a resouce-based perspective. International Journal of Human Resource Management, 5(2), 301-326.

Yin, R. K. (2014). Case Study Research: Design and Methods (5 ed.). Thousand Oaks, CA: SAGE.

Zeng, A. Z., Mahan, M., & Fluet, N. (2002). Designing an efficient warehouse layout to facilitate the order-filling process: An industrial distributor's experience. Production and Inventory Management Journal, 43(3/4), 83-88.

Appendices

Appendix 1: Interview guideline

INTERVIEW GUIDELINE

A consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance

INTERVIEW PARTNER	Name: __________________ Position: __________________ Company: __________________
CONTENT	**Pre-Interview** Introduction and welcome Short introduction of interviewer Short introduction of interviewee Short introduction of topic Structure Confidentiality explanation **Interview** General information Corrective maintenance process Influencing factors Performance improvement
INTERVIEW METHOD	Semi-structured personal interviews, supported by interview guideline and auxiliary material (interview guideline, voice recorder, timer, pen and paper)
INTERVIEWER	Florian Lotte

1

DATE __________________

LENGTH

Start: __________________

Stop: __________________

Length: __________________

RECORDING

□ yes

□ no

LOCATION

□ Jobsite

□ Other __________________

SUPPORTING MATERIAL

□ Interview guideline

□ Voice recorder

□ Timer

□ Pen and paper

□ Other __________________

PRE-INTERVIEW

TOPIC		FOCUS AREA	DETAILLED POINTS/COMMENTS
Introduction	0.1	Introduction and welcome	• Welcome and thank you for participation • Possibility of recording the interview
Interviewer	0.2	Short introduction of interviewer	• Name • Project Manager (focus on process optimization) • Doctoral candidate at University of Gloucestershire, UK • Prior studies in business management and international business with one focus area being in logistics • Approx. four years of experience in spare parts logistics projects; approx. 1.5 years project management
Interviewee	0.3	Short introduction of interviewee	• Name • Company • Business area • Number of employees in company • Registered office • Position/actual job description • Length of affiliation with the company/position • Education • Prior experiences with relevance to spare parts logistics/process optimization (examples and in years)
Topic	0.4	Short introduction to the topic	• Short description by mail/phone prior to interview • Expert interviews with approx. experts (operational and strategic) in three business areas, possibly also customers • Process: Call for maintenance – repair of unit (corrective maintenance) • Central questions: What are the key competitive objectives in corrective maintenance, perceived influence factors on the service technicians' performance in terms of service response time in

			corrective maintenance as well as perceived improvement opportunities to this process? • Sensitization for the importance of the topic: reduction in response time/down time, image, quality, safety, etc. → service technicians are key to quick processes • Goal is to create a consensus construction to understand and improve factors affecting service technicians' response time performance in stationary equipment corrective maintenance
Structure	0.5	Structure	• General information • Corrective maintenance process • Influencing factors • Performance improvement
Confidentiality	0.6	Confidentiality explanation	• Information will be handled confidentially • Data only stored on researcher's PC for the purpose of the research • Information that results from study may be published • Personal and company specific information will be neutralized (no name, but position and years of experience shall be included)

INTERVIEW

TOPIC		MAIN QUESTIONS	DETAILLED POINTS/COMMENTS
General information	1.1	How important is spare parts logistics in general for your company?	• How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • What is the approx. share between service and new installation in revenue? • Please rate the importance of spare parts logistics for your organization on a scale from very low, low, medium, high, very high
	1.2	How important is corrective maintenance in spare parts logistics in your company?	• How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • How often is corrective maintenance required? • When does corrective maintenance play an especially important role? • Please rate the importance of the focus on corrective maintenance for your organization on a scale from very low, low, medium, high, very high
	1.3	Please explain the context of your spare parts logistics corrective maintenance business.	• Number of different spare parts items in portfolio • Price range of average parts • Size and weight of average parts • Density and organization of spare parts logistics network • Number of service/spare parts related employees in organization • Number of service technicians in organization • Corrective maintenance only on own units or also on competitor units • Why are quick service response times required by customers? • Downtime costs per unit • Other than financial cost due to downtime • Other important information
Corrective maintenance process	2.1	How does the spare parts corrective maintenance process look like in your everyday work?	• Please explain the process steps from call for corrective maintenance to repair of unit in its steps. Please highlight the main stages. • Can the process steps be categorized as in Cohen et al, 1997, p. 628? (Drive to unit, diagnose problem, *order part(s) if necessary, receive part(s) if necessary,* repair unit), see attachment • In an ideal world, what would the corrective maintenance process look like from the view of a service technician? • In an ideal world, what do you think should be the maximum time required for the corrective maintenance process in your organization? (In total and step wise) • How long does the corrective maintenance process take on average in reality? (In total and step wise) • Where do you see the highest deviations between reality and an ideal process?
	2.2	Is the service response time in corrective maintenance measured already?	• How is it measured, if at all? How is the performance? Are certain process steps significantly different from others?
	2.3	Are there clear structures/rules for the corrective maintenance process?	• Is the corrective maintenance process formalized/the same for everybody or does everybody decide for themselves? • Who is responsible for the corrective maintenance process? • Are there clear rules on what to do in the event of need for corrective maintenance?
	2.4	Why do break-downs occur?	• Why do break-downs of units usually occur? (Wear and tear, vandalism, technical errors, age of unit/parts, etc.) • What is the most common reason for a unit break-down? • Which parts of the unit are usually the causes for break-downs? (Electrical, mechanical, wear and tear, others)
	2.5	What are competitive objectives in corrective maintenance?	• Time, quality, dependability, etc. • Effect on response time/speed
Influencing factors	3.1	How is the service technicians' performance in corrective maintenance influenced?	• In each process step, by which factors is the service technicians' performance influenced?

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	3.2	What are main factors in each process step that can be influenced operationally?	• What are factors that influence the drive to the unit that can be controlled? (Accessibility of unit (keys, permissions, etc. available), geography (inner city, etc.), proximity to unit). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the diagnosis of the problem that can be controlled? (Part identification, experience, know how, training, supporting material and tools). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the ordering of the right parts that can be controlled? (Communication with purchasing department and warehouse/back office, ordering process (complexity), supporting tools and devices). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the receiving of the right parts that can be controlled? (Communication with purchasing department and warehouse/back office, delivery process (in-night services, PUDOs), supporting tools and devices, availability of spare parts). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the repair of the unit that can be controlled? (Training, experience, know how, tools). Please elaborate.

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			• Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • If only one process step could be influenced, in which order would you prefer optimizations to take place?
	3.3	What are other indirect factors that can be influenced strategically?	• What are other factors that may have an influence on the performance of the service technician? (Amount of work/units per service technician, customer contract specialities, out of office times, etc.) • Please rate the importance of these strategic influence factors compared to the operational influence factors from very low, low, medium, high, very high
	3.4	What are factors that cannot be influenced?	• Please give examples of uncalled events that influence the process but cannot be overcome (traffic jams, etc.) • Please rate the importance of these factors compared to the operational influence factors from very low, low, medium, high, very high

Performance improvement	4.1	How might the negative impacts on the service technicians' performance in corrective maintenance be overcome?	• What does a service technician do to overcome the obstacles in each process step already?
			  o Drive to unit
			  o Problem diagnosis
			  o Ordering
			  o Receiving
			  o Repair
			• What are further possible solutions to improve the service technicians' performance?
			• Please rate these in terms of perceived effort/cost to implement as well as perceived benefits from implementation
			• Why do you think these improvement recommendations have not already been implemented/further developed?

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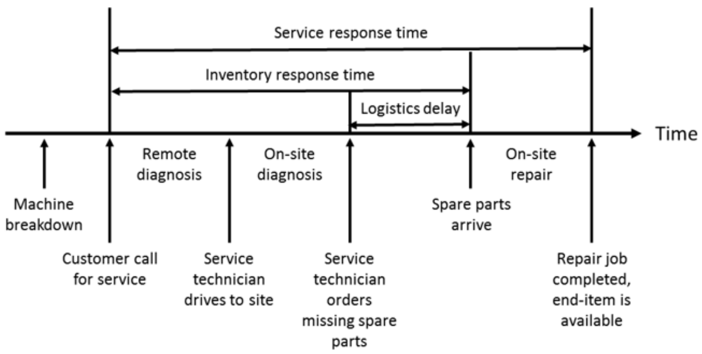
			• Besides cost and implementation effort, what would need to be considered for an implementation? • What would be the effect/benefit of the implementation of these improvement ideas? (time reduction in which process step, how much time reduction, cost savings) • What might be possible downsides of the improvement ideas? • If only one of the innovation/ideas could be looked at in further detail, in which order would you rate them?

ATTACHMENTS



Service response time (Own figure based on Cohen et al, 1997)

Appendix 2: Summary table of interview key points used during the interviews and observations

Topic	Main Questions and Sub Questions	Inputs from Interviewees
0	Interviewee-Number	
0	Business Area	
0	Position	
0	Region	
0	Years of Experience	
1	**How important is spare parts logistics in general for your company?** • How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • What is the approx. share between service and new installation in revenue? • Please rate the importance of spare parts logistics for your organization on a scale from very low, low, medium, high, very high	•
1	**How important is corrective maintenance in spare parts logistics in your company?** • How can the importance be seen? (Revenue, strategic importance, image, competitive advantage, etc.? • How often is corrective maintenance required? • When does corrective maintenance play an especially important role? • Please rate the importance of the focus on corrective maintenance for your organization on a scale from very low, low, medium, high, very high	•
1	**Please explain the context of your spare parts logistics corrective maintenance business.** • Number of different spare parts items in portfolio • Price range of average parts • Size and weight of average parts • Density and organization of spare parts logistics network • Number of service/spare parts related employees in organization • Number of service technicians in organization • Corrective maintenance only on own units or also on competitor units • Why are quick service response times required by customers? • Downtime costs per unit • Other than financial cost due to downtime • Other important information	•
2	**How does the spare parts corrective maintenance process look like in your everyday work?** • Please explain the process steps from call for corrective maintenance to repair of unit in its steps. Please highlight the main stages. • Can the process steps be categorized as in Cohen et al, 1997, p. 628? (Drive to unit, diagnose problem, order part(s) if necessary, receive part(s) if necessary, repair unit), see attachment • In an ideal world, what would the corrective maintenance process look like from the view of a service technician? • In an ideal world, what do you think should be the maximum time required for the corrective maintenance process in your organization? (In total and step wise) • How long does the corrective maintenance process take on average in reality? (In total and step wise)	•

	• Where do you see the highest deviations between reality and an ideal process?	
2	**Is the service response time in corrective maintenance measured already?** • How is it measured, if at all? How is the performance? Are certain process steps significantly different from others?	•
2	**Are there clear structures/rules for the corrective maintenance process?** • Is the corrective maintenance process formalized/the same for everybody or does everybody decide for themselves? • Who is responsible for the corrective maintenance process? • Are there clear rules on what to do in the event of need for corrective maintenance?	•
2	**Why do break-downs occur?** • Why do break-downs of units usually occur? (Wear and tear, vandalism, technical errors, age of unit/parts, etc.) • What is the most common reason for a unit break-down? • Which parts of the unit are usually the causes for break-downs? (Electrical, mechanical, wear and tear, others)	•
2	**What are competitive objectives in corrective maintenance?** • Time, quality, dependability, etc. • Effect on response time/speed	•
3	**How is the service technicians' performance in corrective maintenance influenced?** • In each process step, by which factors is the service technicians' performance influenced?	•

3	**What are main factors in each process step that can be influenced operationally?** • What are factors that influence the drive to the unit that can be controlled? (Accessibility of unit (keys, permissions, etc. available), geography (inner city, etc.), proximity to unit). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the diagnosis of the problem that can be controlled? (Part identification, experience, know how, training, supporting material and tools). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the ordering of the right parts that can be controlled? (Communication with purchasing department and warehouse/back office, ordering process (complexity), supporting tools and devices). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the receiving of the right parts that can be controlled? (Communication with purchasing department and warehouse/back office, delivery process (in-	•

	night services, PUDOs), supporting tools and devices, availability of spare parts). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • What are factors that influence the repair of the unit that can be controlled? (Training, experience, know how, tools). Please elaborate. • Please rate the influence on this process step on the corrective maintenance process in terms of response time realization on a scale from very low, low, medium, high, very high • If only one process step could be influenced, in which order would you prefer optimizations to take place?	
3	**What are other indirect factors that can be influenced strategically?** • What are other factors that may have an influence on the performance of the service technician? (Amount of work/units per service technician, customer contract specialities, out of office times, etc.) • Please rate the importance of these strategic influence factors compared to the operational influence factors from very low, low, medium, high, very high	•
3	**What are factors that cannot be influenced?** • Please give examples of uncalled events that influence the process but cannot be overcome (traffic jams, etc.)	•

	• Please rate the importance of these factors compared to the operational influence factors from very low, low, medium, high, very high	
4	**How might the negative impacts on the service technicians' performance in corrective maintenance be overcome?** • What does a service technician do to overcome the obstacles in each process step already? o Drive to unit o Problem diagnosis o Ordering o Receiving o Repair • What are further possible solutions to improve the service technicians' performance? • Please rate these in terms of perceived effort/cost to implement as well as perceived benefits from implementation • Why do you think these improvement recommendations have not already been implemented/further developed? • Besides cost and implementation effort, what would need to be considered for an implementation? • What would be the effect/benefit of the implementation of these improvement ideas? (time reduction in which process step, how much time reduction, cost savings) • What might be possible downsides of the improvement ideas? • If only one of the innovation/ideas could be looked at in further detail, in which order would you rate them?	•

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Appendix 3: Database structure

- Doctorate
  - 20120101_Application
  - 20120101_Topic & Concept
  - 20130501_UGlos Registration, Enrolment & Administration
  - 20130502_Induction
  - 20130502_Literature
  - 20130502_Your Innovation Doctoral Program
  - 20130503_Module 504_Reflective Professional Development
  - 20130606_Module 503_Systematic Literature Review
  - 20131130_Module 501_Research Methodology & Methods
  - 20140201_Module 502_Action & Case Research
  - 20140401_Seminars
  - 20140529_RD1
  - 20150101_Doctoral Thesis
    - 01_Example Theses
    - 02_Field Study
      - 01_Business Areas
        - 01_Elevator
          - 01_Process Documents
          - 02_Process Observation
          - 03_Interviews
        - 02_Mining Equipment
          - 01_Process Documents
          - 02_Process Observation
          - 03_Interviews
        - 03_IT Hardware
          - 01_Process Documents
          - 02_Process Observation
          - 03_Interviews
      - 02_Documentation Material
      - 03_Empirical Analyses Results
    - 03_Additional Information
    - 04_Thesis
  - 20151105_Viva Training

Appendix 4: Summary of key points/highlights from the elevator business area interviews

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	0/1E	1/2E	2/3E	3/4E	4/5E	5/6E	13/7E
0	Business Area	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator
0	Position	Director Spares Logistics & Pricing	Service Supervisor	Senior Vice President Global Logistics	Head of Service	Vice President Strategy, Markets & Development (SMD) & Product Lifecycle Management (PLM)	Technical Manager	Head of After-Sales Service
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)	Germany	Worldwide	Central/Eastern/Northern Europe	Central/Eastern/Northern Europe	United Kingdom	Switzerland/Liechtenstein
0	Years of Experience	>20 years	>30 years	>20 years	>20 years	>10 years	>30 years	>20 years
1	**How important is spare parts logistics in general for your company?**	• Fierce competition in the market • A few major players, but especially in service a large number of small/local providers • Every company in the market can service every unit from all companies • Necessary to have outstanding service in order to differentiate • Service and spare parts logistics is a major contributor to revenues and margins in the elevator business	• Spare parts logistics is extremely important as elevators should not stand still • Spares logistics is the backbone to ensure that the right parts reach the unit, which is not always the case • To be quick means to be competitive • Prices are always a factor • In the elevator business, a large amount of the revenues are generated through service, not new installations	• Two parts in spare parts logistics: own products with propriatory knowledge and high profitability; third-party products with low profitability • Spares logistics is major contributor to after-sales business • Preventive maintenance is the main focus, however corrective maintenance cannot be eliminated and is thus very important as well • Tool to ensure customer satisfaction • Revenue from service vs. new installations is 50%/50% worldwide	• Quick service is a competitive advantage provider - customer does not accept to wait for the unit to be put into operation again after days; it has to be done within 24 h • Service contracts are tried to be sold directly whenever a new installation has been sold	• Customer satisfaction and safety are highest goals, therefore the elevator has to be operating: spare parts logistics is essential backbone for this operation • Majority of revenues in elevator business area come from service	• Spares logistics/service is crucial for the business, especially corrective maintenance	• Service is extremely important as it generates high revenues, especially spare parts, and these again especially in call outs and repairs • The best case would be to have 100% preventive maintenance, this is not possible however, therefore high focus on corrective maintenance
1	**How important is corrective maintenance in spare parts logistics in your company?**	• Nobody wants to get stuck in an elevator: Quick corrective maintenance is extremely important • Elevator operators are not interested in the logistics, but simply want the elevator to operate all the time and without any issues • Even though preventive maintenance is a main focus area, break-downs occur on a very regular basis • Especially in emergencies, i.e. people stuck in an elevator, service response time is crucial • Corrective maintenance service is a major contributor to revenues and margins in the elevator business	• Highly important • In peak times up to 15 call outs per week, in general around 3-4 per week • Emergency service available 24/7 and is always to be prioritized, otherwise prioritization depending on where the unit is located (hospital vs. business customer vs. apartment building) • Customer is king, reaction time latest by the next day (depending on importance and service contract) • In branch area, 13 service technicians are employed for maintenance and repair with revenue of approx. 140,000 € per month (only repairs and maintenance) • Service is important because otherwise it costs the customer production loss or loss of functionality and the company bad reputation, penalty payments, stress, etc.	• Performance strategy (e.g. units running, quick reaction times) is more important than net working capital-strategy (e.g. reduction of stock to a minimum) as repair is only possible if part is available • Split between preventive and corrective maintenance is not 100% differentiable • Repairs make up approx. 30-35% of all after-sales business (with call outs covered in full maintenance contracts approx. 50%) worldwide	• Corrective maintenance is of major importance (repairs and service contribute highly to revenues) - internal transfer price issues need to be considered	• Full maintenance contracts and performance based contracts (downtime costs penalties): goal is quick and cost efficient repairs and spare parts logistics • Partial maintenance contracts: Possibility of generating additional sales through spare parts logistics • Internal processes for qiuck delivery of right parts to unit are of key importance • Core issues are waiting time and customer retention • Different requirements in different regions: 4 maintenance visits required in Germany per year by law, in France 10 visits per year required by law per year • Average of 1.5-2 call outs per elevator per year in Europe	• Especially corrective maintenance is crucial to the business: This department puts units back to operation and is the face to the customer, in case a final solution cannot be offered, this department can manage to find work arounds to temporarily solve an issue until the final fix can be made - without this, the unit would have to be taken out of operation, this is especially important in hospitals, old people's homes, etc. • As this department is the face to the customer, the image of the company depends on the technicians	• Corrective maintenance is major driver for revenues • Especially the identification of the right parts is of key importance in corrective maintenance • On average 2.1 call outs per unit per year in Switzerland/Liechtenstein (approx. 9.400 units) • Quick service is extremely important to minimize downtimes of units (customer satisfaction, cost & penalties minimization depending on service level agreement) - oftentimes, the service level agreement is defined by the customers, especially big customers (Swiss Central Bank, Coop Supermarket, Migro Supermarket, UBS, Credit Suisse, etc.) with high penalties especially in core locations (e.g. Bahnhofstr. Zurich, etc.) • In emergencies, corrective maintenance is highest prio to rescue locked people
1	**Please explain the context of your spare parts logistics corrective maintenance business.**	• 4,500 out of approx. 11,000 employees are service related • Large portfolio of elevators spread across the region • Portfolio in large cities and remote areas • Spare parts portfolio of approx. 8,000-10,000 different parts due to the nature of the market, where every company can service every unit • 200-400 A-parts • Weights and size vary, usually parts are fairly small and weigh less than 3 kg however • The most expensive parts are controller boards (multiple thousand Euros) • Door panels are the largest parts (which are not a modernization) • Different types of service level agreements exist • The service technicians play a very important role as they are the link between the company and the customer • Also, they have an extremely high impact on the service response time after a break-down	• Comparably spread out area of operation, with high density cities and rural areas alike • 31 branch areas in Germany • Call outs cannot be planned • Spare parts in the range up to 25kg, usually a lot less however, e.g. breaks, magnets, etc., size of parts is not an issue in this business as everything can easily be transported or shipped • Parts that are not available in the catalog anymore, but are in stock, will remain in stock in the local warehouses for a specific area of operation • For old units, parts are exchanged among branch areas and technicians • Used spare parts are not resold • Car stocks play a significant role, usually 35-50 different parts that are enough to fix most of the problems, even during a call out • In Germany, usually all requested parts are available within 24 h and are usually sent to back office rather than directly to site	• Decentralized spare parts business, very fragmented with different article codes in different locations for the same part • Estimation of approx. 100,000 different parts in portfolio (50% own vs. 50% third-party parts) • 24,000 service technicians worldwide, similar amount of stocks worldwide (including car stocks, technicians' stocks, etc. up to 35,000 stock locations) • Every country has individually organized branch structures with warehouses • In addition, there are usually central stocks per country and the warehouses of the manufacturing centres • Customer stocks (e.g. at hospitals, airports, etc.) also exist • Large amount of stock locations is a question of efficiency (average service bill equals 200-800 €, drive to unit costs approx. 100 € (which thus is a major contributor to the price and making a second drive to the unit highly ineffective with service costs rising by 20-40%): efficient planning can increase benefits drastically	• Pure subcontracting of service is a trend at the moment - however importance of service should be unique selling point and focussed on internally • Customer experience is important for competitiveness especially during call outs (example: pub, only with friendly and knowledgable service, the customers will come back; technicians have to live that and identify with the company) • Prices for parts vary (own products, third party products, sub provider products, commodities, copies from Asia, etc.) • Large portfolio of different parts exists • Third-party parts play a big role in spare parts logistics for elevators	• 50%/50% own vs. third-party equipment • Approx. 300,000 elevator units under maintenance in Central/Eastern/Northern Europe, thereof approx. 150.000 third-party units • 175 branches in these regions, 11,000 employes, 7,000 in service • Response times are usually agreed in service level agreememnts with the customer, in emergencies action will be taken immediately	• 3 types of service contracts exist: oil and grease, which only includes oil and grease plus minor adjustments and visual observations on the lift - here the customer pays for everything that exceeds this service; basic service and break-downs - once hours of service that were contracted are exceeded, the customer will pay for that; full maintenance - everything is included: here it is important for the company to focus on preventive maintenance to keep costs to a minimum • The big four companies (Otis, KONE, ThyssenKrupp, Schindler) deliver spare parts within one day • As in the units under maintenance, a lot of third-party equipment is included, these units will need to be serviced with equal quality levels than one's own units	• Approx. 250 employees in Switzerland/Liechtenstein, out of which 103 are service technicians, approx. 9,400 units • Technician services elevators on planned routes with planned maintenance and service times allowing for call outs and small repairs to be integrated into the schedule • Units under maintenance per technician does not give an accurate guidance for needed maintenance time, much rather on an individual level the levels of the elevator and also the location (in the mountains, etc.) has to be considered in order to calculate the planned maintenance time for a unit • Approx. 9,000 different parts from screws, light bulbs, push buttons, etc. to doors and frequency inverters are in the portfolio of this region • Major parts to be used are generally small and not very heavy (rollers, relays, batteries, etc.) • One central warehouse in addition to two smaller warehouses and car stock in this region (4.5 warehouse employes + 5.5 purchasing employes)

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	0/1E	1/2E	2/3E	3/4E	4/5E	5/6E	13/7E
0	Business Area	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator
0	Position	Director Spares Logistics & Pricing	Service Supervisor	Senior Vice President Global Logistics	Head of Service	Vice President Strategy, Markets & Development (SMD) & Product Lifecycle Management (PLM)	Technical Manager	Head of After-Sales Service
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)	Germany	Worldwide	Central/Eastern/Northern Europe	Central/Eastern/Northern Europe	United Kingdom	Switzerland/Liechtenstein
0	Years of Experience	>20 years	>30 years	>20 years	>20 years	>10 years	>30 years	>20 years
2	**How does the spare parts corrective maintenance process look like in your everyday work?**	• After break-down of unit, customer calls and is forwarded to call centre • Call centre sends notification to service technician, who is responsible for the unit • Service technician goes directly to the unit or plans a visit along his service route depending on urgency • At site, service technician identifies the issue • Optimally, elevator can be fixed right away with tools and spare parts available in car stock • If not, the missing parts have to be ordered • The parts, once available, will be given to the service technician (PUDOs, overnight deliveries, pick-ups from the warehouse, etc.) • The service fitter then solves the issue • The timeframe varies on the urgency of the issue • Similar in ATMs, weighing systems, etc.	• After break-down of unit, customer calls and is forwarded to call centre, which contacts service technician (immediately in emergency, on average 30 min, in worst case scenario approx. 1 h) • Technician drives to site (times depend on urgency and customer contracts) • Diagnosis of the issue can take only a few minutes and up to a day in complicated cases, the average being 1.5-3 h • Technician gets customer approval for exchange of parts and incurred costs (which can be multiple thousands of Euros) • Lately, service to automatic doors has been introduced; here delivery to service technicians' cars is possible • Similar in automatic doors	• Almost all countries have call centre structures where the customer calls • Within hours of operation, service technician is informed and will take care of the unit on his daily route/schedule • The exception is an emergency with locked people, where immediate action takes place • Once on-site, technician will try to put the unit back into operation with the available parts (approx. 70% of all call outs can be solved without spare parts ordering; when a part is needed however, he/she uses all available stocks, e.g. car, colleague, branch, local electro markets, etc.) • In approx. 30% of the cases, the technician has to order a part • Identification through catalog, but usually help is required through back office (usually a description and a picture are then sent to a supervisor or purchaser, etc.) • If within a 2 h maximum, the issue has not been solved, an escalation to a specialist is done, where special repair technicians, sometimes even specialized only on certain equipment or electronical parts, etc. come in to help out • If service is required outside of service hours, emergency technicians, who then cover a larger area and have less know-how on certain units (as these are not their general units), will be sent to site; here the chance of ad-hoc problem solving decreases • In normal scenarios, an issue can be fixed within a day (80-90% of the cases) • Special cases (hurricanes, high water, overload of controllers, etc.) can lead to longer out of service times (10-20%) • In emergency cases, the lived expectation (no rule, no law) is that after 20-30 minutes after the emergency call an evacuation has been initiated (Germany); if nothing happens within 1 h, the fire fighters will come in; this is similar in other mature markets • Similar in other industrial equipment and machines, air conditioning, washing systems and petrol stations	• Allocation of job to service technician • Access to unit • Identification • Ordering • Receipt of parts • Repair • Similar in air conditioning, heating systems, escalators • Elevators are commodities	• Once a job has been assigned, service technician will drive to site and identify the issue • In the best case, elevator can be fixed right away • Otherwise spare parts will be ordered, eventually delivered and then the unit will be fixed • Similar in automatic doors	• Customer calls branch, which will then call a service technician or send a message electronically; depending on the business this technician is currently doing, he/she may accept or refuse the call out - in case of refusal, another technician is informed right away • The technician will then go to the unit (prioritization for hospitals, old people's homes, etc.) • Identification of problem, fix it with available parts or order parts, which are not available in car stock • Sometimes it takes more than a week to receive the needed spare parts - work around solutions are of key importance - otherwise image problems may arise • Parts are received through various channels and the unit is fixed • Furthermore, sometimes recommendations are given to the customer to improve the unit (modernization, etc.) • If the technican cannot fix the problem, he/she will call for assistance locally. For third-party units, an expert department focussed on third-party equipment can also be contacted - this will however increase waiting time for the customer and the unit to be repaired • Similar in various other industries	• Call centre available and notifies technican after incoming customer call • Technician goes to unit and identifies the issue • If a fix of the issue will cost more than 500 CHF, a repair offer will need to be made, below 500 CHF, check if the needed parts are in the car stock, otherwise the technician will get the part from the nearest stock location or will have it delivered to his house (PUDO) or car (in-night delivery), before he/she repairs the unit • If a part is not on stock, especially third-party parts, ordering can take multiple days up to a week or more • If a high prio unit breaks down, sometimes unavailable parts are taken out of operating units in order to have the high prio unit running until the needed parts arrive • Shipments of parts are directly sent to the technicans • Service technicians service the same units in order to be familiar with the portfolio, customers, etc. - customer orientation is main objective; when there is a change of technician, this usually means to build a new level of trust with the customer • Unemployement rate in technical jobs is at nearly 0% in Switzerland/Liechtenstein, making it very hard to find good quality employees • Similar in air conditioning, other fixed units, construction equipment
2	**Is the service response time in corrective maintenance measured already?**	• Service response time measurement is up to the local units, a general measurement is not available at the moment	-	• At the moment no KPI measurement in branches	• Number of break-downs per unit is measured in some regions, however no group wide reaction time/service response time KPI is measured	• Cancellation rate is measured, but not the service response time	• Response time is measured in the United Kingdom individually on branch level, however not centrally monitored	• Response time is measured and analyzed per customer (also in Austria) - infos received through call center and mobile devices (live monitoring of technicians) and direct transfer of data to analysis tool; additionally, call out analysis is generated
2	**Are there clear structures/rules for the corrective maintenance process?**	• Structures and responsibilities are up to the local units, a general process is not applicable at the moment	-	• Different in various regions (no formalized structures), however in general the same process worldwide	• Differences are present region wise, however in general similar	-	• Individual organization on branch level	• Clearly structured with process diagrams, etc.
2	**Why do break-downs occur?**	• Wear and tear are usually main causes for break-downs as well as electrical problems and vandalism	• Mainly doors as they wear and tear	• Currently not yet monitored, but in planning phase, however this requires the generation and analysis of a lot of data • Out of experience, 50% doors and 50% electronical problems are the main issues, plus some other exceptions • The more stops an elevator has, the higher is the percentage on door issues (they operated the most and have the most contact to people, also they are the link to the bulding)	-	• Only in rare occasions material issues, usually door and electrical issues • Usually higher break-down rate in the morning and evenings, when the utilization is the highest • Special cases for break-downs can be due to thunderstorms in the summer, power cuts, or in ski season a lot of gravel in the elevator • Break-downs can also occur when they are caused by people (mishandling, vandalism, etc.)	• 80% of break-downs in the United Kingdom happen due to mechanical door problems • Other issues are caused by inverters and in public places also vandalism • In office buildings, wear and tear is more common than elsewhere, in supermarkets oftentimes damages occur due to trolleys being pushed against the elevator incidently for example • The older the units are, the more they fail, the higher quality the elevator (Otis, KONE, ThyssenKrupp, Schindler vs. cheaper brands), the more robust they are	• Doors are the main driver for call outs, another factor is the quality of products
2	**Whare are competitive objectives in corrective maintenance?**	• Speed, quality, price, flexibility, dependability, prevention, safety	• Safety, prevention, timeliness, flexibility, security	• Prevention, price, speed, dependability/availability, safety	• Price, safety, prevention, speed	• Price, safety, availability/dependability, speed, flexibility, quality	• Flexibility, safety, prevention, security	• Flexibility, quality, safety, prevention, dependability

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	0/1E	1/2E	2/3E	3/4E	4/5E	5/6E	13/7E
0	Business Area	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator
0	Position	Director Spares Logistics & Pricing	Service Supervisor	Senior Vice President Global Logistics	Head of Service	Vice President Strategy, Markets & Development (SMD) & Product Lifecycle Management (PLM)	Technical Manager	Head of After-Sales Service
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)	Germany	Worldwide	Central/Eastern/Northern Europe	Central/Eastern/Northern Europe	United Kingdom	Switzerland/Liechtenstein
0	Years of Experience	>20 years	>30 years	>20 years	>20 years	>10 years	>30 years	>20 years
3	**How is the service technicians' performance in corrective maintenance influenced?**	• See next points for details	• See next points for details	• See next points for details	• See next points for details	• See next points for details	• See next points for details	• See next points for details
3	**What are main factors in each process step that can be influenced operationally?**	• Large number of service technicians in order to secure proximity to units, even in rural areas • Keys to the units are available at facility management offices or key boxes usually • Delays are caused when facility management is not present • Permissions in high security areas, e.g. prisons or nuclear power plants may cause delays • Parking in large cities causes trouble very often • Identification of parts is crucial and a major contributor to delays • Catalogs need to be structured and include clear specifications and all parts necessary • Information on parts lacking • Mobile devices can support, if available • The combination of identification and having the right supporting material, i.e. catalogs, devices, car stock, tools, etc. is extremely important • Knowledge, training and know-how have an impact on service response time • First time fixes have a major impact on response time • Ordering has less influence on the response time • Once a technician is on-site and has identified the issue, most of the problems have been taken care of • Best case: spare part is in car stock, otherwise ordering through phone or mobile device, if available • The ordering process complexity has a high impact (direct ordering through laptops or mobile devices vs. identification in a catalog and then ordering through the back office (sophistication of this process varies from area to area)) • Good supporting material and tools are of importance in this case again • In-night deliveries, PUDOs not possible everywhere due to legal restrictions and company guidelines • Pick-ups from the warehouse cause additional driving time • Location is important: in Europe parts can be moved quickly, in Brazil it takes around 3-4 weeks to bring a part from Sao Paulo to the Amazon Rain Forest (Manaus) • To repair, experience and training are key to success • Especially electrical parts cause issues frequently • A support centre exists for third-party electronic equipment	• Pricing and local purchasing not efficient • Purchasing own parts from competitors is often quicker, but more expensive, than buying at the own manufacturing centre • Access to site usually is not an issue, key boxes exist or responsible person is available • Catalog is extremely poor (no explanations, bad pictures, use of electronic devices could be improved, no drawings, no 3D-models) causing a lot of wrong orders, which are extremely expensive • ERP-system is very good (includes history of unit, customer requests, paperless signing, service- and diagnosis-pamphlet, comments on job can be done right away) • Communication between colleagues plays a major role, e.g. on supervisor meetings, which are unstructured and irregular at the moment • Ordered parts are usually picked up from back office and only rarely ordered directly to site • Exchange of parts is usually not an issue as long as the right part has been ordered (on average 1.5-2.5 h, in rare occations 0.5-1 h or 7-8 h) • Key customers have on-site storages of certain parts, e.g. Veltins-brewery in ordere to reduce reaction time to a minimum to avoid production loss • Training is very important • The well being of the service technician plays a major role in his/her motivation • Knowledge and experienence are extremely important • High quality cars with big trunks, navigation system, headsets and good tools are important	• Call at service centre (no intelligent questions for remote service at the moment, also no differentiation between call out and emergency): 20-30% of the call outs could be handled remotly • Planing of service (own plan by technician vs. central dispatching): quicker and more efficient is central dispatching, however this is expensive; usually the technician is left with some freedom on his route and the choice on which unit to deal with causing inefficiencies • Use of cell phones and ERP-systems on mobile devices are important • Access to site is usually not an issue (keys and responsible people are usually at site) • Parking is an issue in big cities • For diagnosis, intelligence in the system is missing • Clear diagnosis structure is benefitial, e.g. when the technician has lots of experience, knows the unit, knows the building, etc. • Too quick diagnosis, missing the core issue, is often a problem • Catalogs need to be a help for the service technician • Tags with article numbers are theoretically practical, in reality, due to dirt, third-party units, barcodes not made to help competition, etc. not really applicable • Ideally, the required part is in the car stock • A supply chain of parts is highly important • Approval process with customers is highly important and should be standardized (e.g. in USA all service up to 2.500 $ can be done by technicians without approval), otherwise long process with back office involvement, sometimes even additional drives to hand in approvals at the back office, etc. • Efficient stock levels are important, however performance-based strategy is not possible with full NWC focus • Training and knowledge and exchange of information is key to have a quick repair while portfolios of parts and units grow constantly (eventually hard to handle)	• Third-party parts and all adjacent topics (storage, identification, sourcing) is a key issue (e.g. in UK 80% third-party units under maintenace; the service technicians know more about third-party units than own units, however this knowledge is not captured or shared; simultaneously call outs on own units cause issues more often) • IT support in the entire process is extremely important and not optimal at the moment • Pricing and transfer pricing of parts is important • Car stock is a big influence on response times • Trainings are a difficult topic, but need to be enforced • Major issue is for technician to know everything with the increasing amount of technologies, units, parts, suppliers, problems, etc. • Parts not being produced anymore cause major delays in repairs as alternatives are missing • Parts have different numbers in different areas despite being the exact same parts (own parts, third-party parts, sub supplier parts, etc.) • All countries use different spare parts catalogs • Driving and waiting times are major topics for long reaction times • Delivering identified needed parts quickly to site is of major importance • Training regarding face to the customer is extremely important • Retention programs to be installed for customer orientation, net promoter score, offering solutions to the customer, communication • Big key chains cause trouble in Germany/Netherlands - loss of key costs around 200,000 € on average, as at site a lot of keys have to be exchanged - high cost risk • Long drives, especially in condensed cities, e.g. Stuttgart or London, cause major delays • Identification of parts is one of the major contributors to long response times • Heavy tools and parts need to be transported, sometimes multiple levels	• Access to unit: usually the technican has a fixed area of operation with fixed portfolio of units (knowns the unit, knows the building, knows the customer) • Usually key lockers are available on-site to store the keys to access the unit • Special cases, e.g. islands and rural areas, e.g. Sylt island, the firefighters are called in case of emergencies, as service technicians from the mainland would need too long to get there • Identification: having the right tools is essential • Technicians usually are only equiped with cell phones, not smart phones, so they cannot do anything except call • Tools cause delays as oftentimes they are not carried to site right away but are picked from the van/car once the issue has been identified causing delays • Ordering takes a lot of time in some areas usually (e.g. second brand companies only have hard copy catalogs, back office employees help find parts online, causing lots of telephone communication) - especially electrical parts seem to be an issue • Delivery of parts is organized individually in all regions. Very common are pick ups from the branches • Repairs are influenced especially by knowledgeable technicians with high know-how	• Identification is hard because of the variety of catalogs available • Progression of technology plays a big role - back in the days no phones, everything paper based • Flexibility in all aspects is of key importance in this process • Experience is very important • Access to unit depends on wherre it is (in some cases it does not take more than 2-3 minutes, in high security hospitals, etc. it may take up to a couple of hours to be granted access to the building); in power plants, not more than 1 job per day can be scheduled as it takes very long to go through all the processes to be granted access • Driving takes up the majority of time • Receiving parts depends on which parts are needed - a lot of parts are within the car stock (consumables, rollers, relays, etc.), bigger and more expensive parts are stored in branch, which then requires a delivery or pick up process, which will increase the response time • Pick up of parts depends on urgency, in not as urgent cases, a delivery mode will be chosen • Repair times again depend on what needs to be done: For simple break-downs no tools and parts are required at all, in other cases special tools are required, which need to be picked up from the branch or warehouse • Expert structures are in place in order to assure that if one technician cannot fix an issue, a more experienced or specialized technician will come in to support up to a full special task force crew with special equipment and tools - repair time can thus vary from less than an hour to 1-2 weeks	• Mountain regions cause trouble oftentimes, otherwise maintenance time per unit is calculated an allocated to service technician, who will then be given a route with a number of units for a specific day • Access to airports takes longer than the normal case due to safety requirements, the same goes for hospitals and prisons, etc. - it is calculated into the maintenance time and therefore usually does not cause much trouble (good organization and preparation are important) • In identification, the catalog causes the biggest trouble as well as the availability of parts from the manufacturing centres • All parts are available on the mobile device (PDA), however only about 40% of the parts have pictures, there are no drawings and new parts are not photographed at all • In case, a technician cannot identify a part, he takes a picture and sends it to the back office (supervisor, repair sales department, warehouse, etc.) for research • Technician usually takes notes on own units • Technician cannot order directly through mobile device • Delivery of stock parts is working well (different options, e.g. PUDOs, in-nights, pick up from warehouse, etc.) depending on case-by-case decision - delivery from manufacturing centres and internal supply of equipment through second brands, etc. is not optimal • Technicians are trained every two years on customer orientation • Experience is very important, new technicians and technicians from other business backgrounds are usually trained on-the-job by experienced technicians for about 3 months • Right tools are extremely important to solve issues and to diagnose them in the first place
3	**What are other indirect factors that can be influenced strategically?**	• Strategic factors have a medium influence on the process and the service technicians • Units under maintenance per service technician, customer contract specifications, out-of-office times and availability of parts through colleagues have a medium effect	• High quality employes are hard to find and need to be motivated to stay with the company	• Influence not measurable • Motivation of technicians (solver of issues or proactive eliminator of issues) • Who is motivated by what? Bringing together the goal of the organization, customer requirements, motivation of the technician and the measurement is the key task	• Agreed response times, but higher customer requirements, e.g. security-pass, health & safety, etc. (chemical industry, prisons, airports, military, banks, etc.) can cause delays and thus higher costs • Changing world (digitalization, etc.) require always new concepts and more advanced customer orientation, e.g. use of social media instead of telephones, etc. • Fluctuation of technicians is a serious issue	• Out of office times influence the response time	-	• Strategic logistics and internal supply chains need to be in focus by top management
3	**What are factors that cannot be influenced?**	• Traffic jams are not a major concern • Weather conditions are not a major concern	• Infrastructure cannot be changed, but can be dealt with depending on region • Traffic jams, highway quality and strikes	• Traffic jams	• Traffic jams	-	-	• Customs to and from Switzerland/Liechtenstein usually costs one day in ordering/delivering • Weather, such as snow in the mountains cannot be influenced (is clearly stated in service level agreements, too)

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	0/1E	1/2E	2/3E	3/4E	4/5E	5/6E	13/7E
0	Business Area	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator
0	Position	Director Spares Logistics & Pricing	Service Supervisor	Senior Vice President Global Logistics	Head of Service	Vice President Strategy, Markets & Development (SMD) & Product Lifecycle Management (PLM)	Technical Manager	Head of After-Sales Service
0	Region	Central/Eastern/Northern Europe & Worldwide (for certain projects)	Germany	Worldwide	Central/Eastern/Northern Europe	Central/Eastern/Northern Europe	United Kingdom	Switzerland/Liechtenstein
0	Years of Experience	>20 years	>30 years	>20 years	>20 years	>10 years	>30 years	>20 years
4	**How might the negative impacts on the service technicians' performance in corrective maintenance be overcome?**	• Route optimization and scheduling have to be focussed on • Communication with the customer • Know the customer, know the units through having the same service technicians take care of a set portfolio of units • Unique bar codes and identification numbers on the most relevant parts • Online catalogs • Mobile devices • Further identification levers such as dimensions, colours, descriptions, etc. • Explosion drawings • Electronically available information on re-order times, availability, etc. • Improve the data flow of key information to fill the data base (from construction on) • Direct ordering through online/electronic catalogs • Personalized information on spare parts portfolio on service technician's laptop/mobile device • Harmonized car stocks with personal adjustments depending on units under maintenance • Automatic replenishment of car stock • Make all car stocks available to all technicians • Scanning by barcode to keep track of stock movement • Implementing specialized experts task force teams • Mobile devices can also store customer information • Supporting network of central stocks that has major parts available all the time is the necessary backbone • Define multiple options to deliver to customer/service technician in order to be flexible and react to circumstances • Right tooling with high quality equipment needs to be available • Regular trainings • General focus on preventive maintenance is highly important • Never lose track of local circumstances and necessities • Customer focus • Improvements in this area are a continuous need	• Reduction of car stocks to standard portfolio plus individualized stock depending on units under maintenance, then give few specialized technicians extra stock depending on their function (1-maintenance, 2-incl. call outs and emergencies, 3-expert, 4-commissioning) • Automatic refill of car stock • Help and exchange amongst colleagues should be even more enforced • Direct delivery to service technicians' cars, however keeping in mind that communication and exchange between service technicians is important • Improve electronic devices and catalogs (including direct ordering, better pictures, better descriptions, 3D-drawings, etc.) to reduce wrong orders • Focus on slogan "Made in Germany" more, as it is a big point in international sales • Introduce ERP-systems for technicians worldwide where possible • Improve structure of supervisor meetings, and have them regularly • Trainings are important and should be enforced regularly • High quality cars with big trunks, navigation system, headsets and good tools are important • High quality employes are hard to find and need to be motivated to stay with the company • Up to a certain amount of money for spare parts and the job, the technician should be enabled to do this without a customer signiture	• Introduction of smart questions in call centers for remote service including how to deal with different situations-manual; this could also be used in preparation for the service technician in case remote service does not solve the issue, furthermore specialized technicians can be contacted right away in specific cases in order to only have one drive to the unit to solve the issue • Differentiation between call outs and emergencies at call centres including how to deal with the situation-manual • Routing and dispatching of service technicians • Usually special parking permits can be obtained, sometimes a note in the windshield, especially in emergency cases, will help in solving parking issues; otherwise new concepts, e.g. motorcycles, using the subways, mobile service cars, etc. should be further looked into • Concept in Sao Paulo, Brazil: Technician is driven to site by a driver, larger stocks are in the trunk and the driver drives around the streets until the job is done; alternatively motorcycles with backpacks are given to the technicians or cards for busses and trains; sometimes there are even resident technicians, who only operate in certain locations (e.g. airport) • Intelligent data systems for remote control of units, preventive maintenance and issue diagnosis • Call outs should be dealt with by the technician who usually services the unit (knowledge of the unit, the customer, the building, etc.) • Electronic catalog on mobile devices with all required information, pictures, drawings, possibility to order, etc. • Intelligent identification devices such as visual/image recognition software, call centre with google glasses for support, etc. are options that are highly relevant (mix of solutions, even with barcodes and RFID, possible) • Ideally, the technician has access to stock lists of other technicians, warehouse, etc. to give ad-hoc information to the client when he can fix the issue • Agree on service levels with suppliers • Install different modes of delivery (direct shipment to site, over night delivery to car stock or PUDOs) • Implement alternative options for quick delivery (motoboys in Madrid, pensioners in the Netherlands, in the future even private people through Uber, etc.), which are less expensive and more flexible then courier services • Car stock in countries like Brazil, where technicians might live in dangerous areas, not possible because of theft • Approval of service up to a value of x should be implemented without customer signature in order to speed up process (contractual adaptation) • Focus on performance rather than NWC without completely neglecting NWC obviously • Implement forcasting algorhythms for re-order points, target stock levels, economic order quantities, etc. • React to growing portfolio possibly by specialization, remote service through call centres, module exchanges instead of single parts with adjacent analysis in back office, parametrization (e.g. Apple solves all system issues for all units through cloud), etc. • Strategic question: Can it be the goal of the organization to provide maintenance free units, when after-sales is a major provide of revenues? The customer does not want to have issues with the elevator and have reasonable costs involved (total cost of ownership), as a company revenues are generated through maintenance and repairs, while image and costs need to be considered. It must therefore be the goal to have maintenance, but solve the issues highly cost efficient and quickly in order to satisfy the customer requirements and ensure high margins (main points are: remote service, ad-hoc fixes (first time right), data management and new identification concepts, technician qualifications) • Usually, if a unit has had 3 call outs within a short period of time, it will be put on a bad equipment list, and a thorough check up will be initialized or a modernization (machine, controller, etc.) will be considered	• Visualize all spare parts in a catalog and webshop (including third-party) and include necessary data for each part • Combine existing catalogs • Unified concept with complete and up-to-date electronically available catalog including drawings and 3D-models, necessary information, etc. • Adjust warehouse structure (e.g. manufacturing centre storages to include third-party parts as well) • Knowledge sharing to be improved, especially regarding third-party units and equipment • Motivation for technicians to stay with the company and reduce fluctuation, thus keeping know-how • Specialization trainings to be offered • Give experienced technicians the option to get a trouble shooter position or office job for remote service in order to capture knowledge • Technical hotline for remote service • Google glasses with back office support or other visual identification of parts including barcodes • Reduction of parts variety through standardization (e.g. like car manufacturers with platform solutions) • Create alternative solutions for parts that are not produced anymore (e.g. through 3D-printing - not possible for electrical parts however): therefore knowledge of production stop for certain parts needs to be transfered well in advance for spare parts logistics to come up with alternative solutions to secure operation of units • Install repair centers for electronic equipment to reuse parts • Unique identification numbers for parts worldwide need to be installed • A technician coming to site should be supplied with a catalog of parts for this exact unit and bill of materials to order • A clear process needs to be implemented to reduce mistakes • Check up regularly on driving and routing options • Service technician has to be enabled to give customer hints on solutions and sell products for prevention • Focus on own service rather than subcontracting • Keyless access to site • Alternative concepts are needed in condensed areas (e.g. motorcyclists or use of public transport by technicians during London Olympics); regional alternatives have to be considered given the circumstances • Help the technician before he goes to site by supporting him with data and information in order to assure first time fixes on-site • Digitalization of equipment is of key importance • Provide tooling that can be carried, less paper through electronic data, mobile solutions including all information needed and selling/ordering options) • Standardized car stocks plus additional parts and tools depending on units under maintenance • If part is not in car stock, direct delivery from another stock location needs to be initiated immediately through the system • For repair, knowledge has to be shared and provided electronically (decision trees, operation manuals, remote service, etc.) • Electronic diagnosis tools (plug & play) to be provided for automated issue identification through ERP-system or diagnosis tool • Knowledge data base • Focus on the technicians, not everything can be done electronically, remote, through tools and systems, especially vis-a-vis communication • Keep social media trend in mind	• Repair busses with bigger parts and tools instead of cars for certain areas/regions • Predefined car stocks with automated refills after use of spare parts • Navigation systems as standard items in every car in order to avoid traffic jams • Geo localization in rural areas is a great option: even though technicians have fixed units, if in a very big area, this technician is in the complete different corner of the area of operation, and another technician from a neighboring area is much closer to the called out unit, it would make sense to send this person to that unit • GPS tracking available in some countries, not everywhere however due to reglementations: disposition can be improved • Health & Safety improvement: dead-man-function on devices (e.g. like in trains) to log into the system regularly in order to make sure everything is alright, especially when working in an elevator shaft alone • Remote monitoring and tracking of data in order to preventively take action, give the right information to the technician during call outs (right parts to fix the issue), and learning by doing • Tacid knowledge and exchange of ideas and know-how (exchange of ideas between technicians is extremely important) • Equip technicians with smart phones in order for them to be able to access catalogs, send pictures, have a flash light, etc. • Optimized tooling (light enough to carry all of it right away), maybe even route optimized tooling is an optimization worth thinking about • Optimize identification of electrical parts • Regular training and exchange of ideas is important for technicians • Easy repair could be introduced by providing repair kits for certain issues • When workaround solutions are used, this knowledge needs to be captured and shareed • Technician must be able to make direct orders through automated processes (including easy return of unused parts) without billing • Every unit under maintenance should have a database of key information • For every newly designed elevator unit, key data should be recorded from the beginning and the engineering/design department should provide key information for spare parts logistics right away (life-cycle management) • Besides all technical and other improvements, the core influence in this process is the technician - motivation, skills, customer orientation, etc. are the key to success	• Capture knowledge on work around solutions and use it to fix problems temporarily • Use of technology, e.g. smart phones to make process easier for technicians (send pictures, access to the internet, etc.) • Individualized catalogs based on serviced portfolio • An exchange of ideas between technicians is essential, e.g. technicians should have weekly meetings in the back office to network, have a coffee and to help each other; the exchange of information cannot be emphasized enough (call out issues, problem solving techniques, swapping parts, ideas, catalogs, etc.) • Also on a supervisor or strategic level, regular meetings should be installed to capture developments, products and ideas (in the United Kingdom every 6 months this happens) • Routing systems on mobile devices to send the nearest technician to a particular site/unit • Better information to identify where to get a certain part (data base on all stocks) • Improve access to the right part (local suppliers, etc.) • Improve information on units and parts on mobile devices • Increase flexibility	• Use technicians from other business areas in markets with low availability of high quality employees and high fluctuation, etc. - especially suitable are mechatronics, car mechanics, electro mechanics • Workarounds, such as using functioning equipment from functioning units for high prio units that have called out should be made available in emergency situations • Use response time measurement technique in other regions • Incorporate process to photograph every new part and incorporate it into the catalog with sufficient information and data (standard work flow) • The identification process has lots of potential for improvement (single article numbers, image recognition, 3D-drawings, pictures from multiple angles, etc.) • Knowledge through notes on own units should be publicly available, in case a substitute has to repair the unit • Direct ordering through catalog/webshop on mobile device • Automatic replenishment of used car stock • Use input of service technicians more (regular meetings and brainstorming sessions) to improve process • Stability of the ERP-system and internet connection in remote locations has to be ensured • Improve availability of stock through entire warehouse network, including manufacturing centres (internal supply chain) • Expert repair structure in place and to be adopted in other regions (small repair to be done by service technician, bigger and more complex repairs will be handled by expert teams with expert equipment, e.g. fork lifts, etc. • Diagnosis tools should identify mostly every issues directly when connected to the unit (also third-party)

Appendix 5: Summary of key points/highlights from the mining equipment business area interviews

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	6/1M	7/2M	8/3M	9/4M	10/5M / 10/6M	11/7M / 11/8M	12/9M
0	Business Area	Mining equpment	Mining equpment	Mining equpment	Mining equpment	Mining equpment/Mining equipment	Mining equpment	Mining equpment
0	Position	General Manager Services	Head of Global Service	Technical Service Manager	Service Manager	Head of Service & Technology/Project Manager	Commercial Manager Global Services	Head of Assembly & Coordination
0	Region	Australia	Worldwide	Sub-Saharan Africa	France/North Africa/West Africa	Worldwide/Worldwide	Worldwide	Germany
0	Years of Experience	>25 years	>20 years	>10 years	>20 years	>30 years/>5 years	>10 years	>25 years
1	**How important is spare parts logistics in general for your company?**	• General trend: service is becoming more and more important in heavy equipment industry • Major shift can be seen from capital investment for heavy machines towards services • After-sales service in Australia is about 70% of the revenue share (80 mio. AUS-Dollars order intake in 2014/2015) • Service is offered to customer as part of a full package in sales stage • Stock made to plan is very important (order it before the customer needs it)	• It must be the goal to not only be a spare parts provider but a service provider and partner to the customer for the entire life cycle of a product • Internal view: High margins in service, therefore needs to be focussed on more; stable market as the base is not as volatile as in project (new installation) market; generation of OPEX out of CAPEX • External view: high class service providers are needed to reduce the efforts of the customer; there is potential on the market as the customer demand rises	• Logistics is very important, especially break-down maintenance & preventive maintenance • Spare parts are very cruicial (delivery times, quality of packaging, transport, wrong/right parts dispatched)	• Regional office generates around 12-14 mio. € of service revenues annually (70% spare parts, 30% maintenance service and repairs) • Compared to new equipment, only approx. 10% of the revenue are generated through services, however the potential is much bigger	• Operation of equipment through customers, also repairs can be done through technicians on-site: Servie provider only comes in for special break-downs, e.g. emergency repairs (corrective maintenance) • Spare parts and service are very important to generate margins (much higher than in new installations)	• Service has major potential (the goal is 400 mio. € EBIT in 14/15, 700 mio. € EBIT in 19/20) • Service is a solid backbone for new installations • Service can generate follow-up business • Service technicians are the face to the customer	• Service is very important for the business
1	**How important is corrective maintenance in spare parts logistics in your company?**	• 80% of spare parts business is replenish stock, 20% urgent call outs • If parts are on stock, delivery to site within 24 h can be achieved, otherwise temporary solutions are needed, as costs are extremely high for out of order equipment (production loss, etc.): this can go up to millions of dollars for extended downtimes (e.g. reclaimer production loss are millions of dollars per h)	• It currently is the goal to solve most issues through condition monitoring and preventive maintenance, this is not possible always however • In cases of break-downs however, immediate reactions are necesssary due to high production loss costs (in general equipment runs 24/7, downtime on average costs 10-40,000 € per h • With high production loss costs, the margins are usually high as the customer is willing to pay for quick service and corrective maintenance	• In Sub-Saharan Africa 50% preventive maintenance/50% corrective maintenance, with a slight trend towards preventive maintenance • 90% of time additional benefits come after solving breakdowns, e.g. spare parts sales, service proposals, etc. • Customers look at service capability of a service and equipment provider before they buy new equipment; the better the provider is in service, the higher the sales in new equipment • Production loss for clients averages around 100,000 € profit loss per hour • Outstanding service generates marketing benefits, especially brand recognition	• 70% spare parts, 30% maintenance service and repairs out of 12-14 mio. € revenue volume • Less than 24 h services/reaction times are required by the customers in general due to loss of production and incurred high costs or further break-down of other important parts through a broken component or part	• In case of corrective maintenance needs, a service technician has to be on-site within 1 day and needs to have a plan what needs to be done in order to repair the unit • Quick support is extremely important (liabilities and contractual facts have to be clarified up front and are usually dealt with parallely by back office) • The overall percentage of corrective maintenance is comparably low, but if it occurs, it generates very high margins • Production loss due to broken-down equipment around at least 10-50,000 € per day for a major client in Germany, other regions and other customers may have even higher losses	• The focus is on preventive maintenance and condition monitoring, however corrective maintenance cannot be neglected as it will always be part of service business • In integrated asset management concept/performance based scheme Overal Equipment Effectiveness (OEE) is a incentive for quick response time	• Prodcution loss for customer is huge, when key equipment fails, therefore quick corrective maintenance is very important
1	**Please explain the context of your spare parts logistics corrective maintenance business.**	• Spare parts can range in size and weight from <1 kg consumables to approx. 40 t crushers • All crusher parts have to be ordered from German manufacturing centre at the moment • All Australian parts are made through local subcontractors • Out of 80 mio. AUS-Dollars order intake, roughly 50 mio. are spare parts • Margins are very high on spare parts • Service centres are strategically located all over Australia (3 centres in total) • The most expensive standard parts are approx. 150-200,000 AUS-Dollars • Replenishment of stock can take up to 10 weeks: the larger and more complicated a part is, the longer the lead time • In urgent cases, a special feature in this business area applies: other customers help out with lending spare parts	• Spare parts can range in size and weight from <1 kg consumables to approx. 50 t equipment and cost anywhere from 10 € - 500-600,000 € • Approx. 25.000 different parts are in the spare parts portfolio in addition to extra/special parts • Service centres are always responsible for certain product portfolios • Warehouse in Münsterland, Germany for instance generally deals with crushing equipment • In case of external ordering, lead times vary from 1-2 days for hydraulic screws to multiple weeks for custom designed parts • Service is mostly done on own units rather than third-party equipment, even though this is also possible	• Some technicians in Sub-Saharan Africa are directly located on-site at main customers • Main branch for Sub-Saharan Africa is in Johannesburg • Another branch is located in Zambia • Spare parts vary in size, weight and price • Prices can be anywhere between 50 € - 5 mio. € • Parts can way up to 110 t (in materials handling even up to 300 t), but can be equally little in size and weight • Heavy tools are needed to service equipment • Both own and third-party equipment is serviced • Customer relationships are very important	• Parts are generally ordered through manufacturing centre in Germany • Portfolio comprises small parts, e.g. rollers, up to 800.000 € parts, the same divergence exists in weights and sizes • 60% of the services are on competitor products • Highly competitive market due to competition from other major players, subcontractors and low cost countries • No stock, only manufacturing on demand, except for very few specific parts • Operation for the entire region based out of France	• A lot of business is done with governmental organizations from various counties around the world • German service centres act as supporters from regional service centres (technical assistance, special task force, general support) • Example Greece: A mine with very bad accessability due to geographical and infrastructural circumstances, had an issue with equipment, for which a specialist was needed to fix it, everybody in the regional organization was busy with other jobs, therefore the German organization was called and handled the issue by organizing for an Indian specialist to travel to Greece within 2 days and fix the unit within a week: Contractual agreements with the customer have to be clarified up front in order to cover costs • Usually there are no maintenance contracts, only special frame contracts for special customers clarify the circumstances only for cases, when service provider's help is required: Normal maintenance is done through operaters themselves • Highly competitive market and business area with lots of local companies and a couple of big global players	• Integrated asset management concept has been introduced at a customer site in Morocco for the first time and will be roled out to further customers now • The goal is to be present on-site directly including warehouse and integrated asset management concept with different options for the customer • Morocco: Step 1 - Development of maintenance processes and structures, audits and definition of KPIs in order to identify target costs for maintenance; Step 2 - Implementation of service team with full responsibility for maintenance inclduing warehouse and preventive and corrective maintenance	• Operational service provider for customer on-site (Germany) • Market situation changes: Customers learn and have high knowledge on their equipment - more and more repairs can be done by them without help from service providers • Preventive systems are in place more and more often to prevent failures from happening: The machines/equipment will shut down before failures cause harm to the equipment • Unique selling points for service providers are contacts to customers, partner companies, statics, container parks with tools, knowledge and experience, spare parts portfolio, especially on propriotary goods, etc.) • 21 technicians placed on-site

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	6/1M	7/2M	8/3M	9/4M	10/5M / 10/6M	11/7M / 11/8M	12/9M
0	Business Area	Mining equpment	Mining equpment	Mining equpment	Mining equpment	Mining equpment/Mining equipment	Mining equpment	Mining equpment
0	Position	General Manager Services	Head of Global Service	Technical Service Manager	Service Manager	Head of Service & Technology/Project Manager	Commercial Manager Global Services	Head of Assembly & Coordination
0	Region	Australia	Worldwide	Sub-Saharan Africa	France/North Africa/West Africa	Worldwide/Worldwide	Worldwide	Germany
0	Years of Experience	>25 years	>20 years	>10 years	>20 years	>30 years/>5 years	>10 years	>25 years
2	**How does the spare parts corrective maintenance process look like in your everyday work?**	• After break-down of unit, a call will reach the service centre and generally a service technician will be on-site the same/the next day • Usually, a repair job can be finished the latest within a few days • As customer has engineers on-site to operate the machines, usually once a service technician arrives, identification of the problem has been achieved already • Remote sercive by phone is a frequently used option • Machine break-downs are comparably rare • Even during Christmas, with parts available, service technicians will be available on-site within 24 h and at least temporarily fix the unit • Similar in heavy equipment	• Issues are identified through experts and technical departments on-site • Remote diagnosis through telephone calls is often the case • In cases of parts being exchanged, oftentimes other parts are exchanged right away • In case of unavailability of parts, provisionary solutions are implemented to keep the unit running until spare part arrives; oftentimes, other customers help out with missing spare parts • 80-90% of corrective maintenance is handled by operater, in other cases service provider is called for help, goes to site, identifies the issue and initiates repair • Corrective maintenanance always has higher priority than other maintenance activities • Triangle of relationship between prices, quality and leadtimes for parts has to always be considered as supplier of service/corrective maintenance to a customer; quality has to be of highest standards, price is less important because of the high production loss costs, therefore the biggest trigger is lead time on the parts and thus the service/reaction time • Similar in shipyards, trains and transportaiton (except airplanes) and other complex equipment	• Once a call comes in at branch/regional office, a conversation about the issue is initiated in order to clarify the situation • Based on what was discussed, a person is dispatched to go to site • Technical assessment is done by senior service manager, resources are planned and mobilized within 24 h or quicker • It is crucial to send very experienced technicians to site as soon as possible to deal with the customer and the issue, the rest of the logistics can be planned in the background • Identification is done on-site • Constant communication with the customer throughout the entire process • Authorization for spares (internal procedure including risk assessment of payment) • Send parts to site and repair unit • Lead times vary largely on the parts • Networking and teamworking are important • If parts are unavailable, see what is available on-site, are there used parts that can be temporarily used • Experienced technician will stay on-site until final fixture of unit • In Sub-Saharan Africa, it takes about 24 h to send somebody to site in Ghana, 8 h within South Africa • Similar in chemical plants, fueling trucks	• Usually the customer calls and sends a description and/or pictures of the problem • Back office immediately develops a reaction plan, offers remote services and advises and sends an expert to site if needed • Oftentimes, temporary solutions are used to fix a problem until a necessary spare part is available (no consumables, mainly strategic/propriatory parts), cracks are welded (high competitive advantage as only very few companies can do that) • Advising the customer remotly generates about 30% added value and is extremely important • Usually bargaining power is on the service provider's side as customers do not have many experts on-site as they do not face issues very often • Response time usually within 24 h, even if reordering of parts takes a year or more (temporary solutions) • Similar in cement, fertilizers, heavy equipment	• Technicians on-site will make most of the issue analysis and identification • Contractual points will be handled through the back office, so they do not interfere with the technicians work (including need for specialistis, travel plans, offer for repair and parts, etc.) • Personal contact to customers and specialists in the different regions is extremely important • Know-how is extremely important, especially with special equipment such as highly complex crushers • Similar especially in heavy equipment	• In service asset management concept every process step in maintenance is in full control of the service provider (or as agreed with the customer) • Focus is on preventive maintenance including condition monitoring (noises, oil levels, sensors in equipment etc. • Remote condition monitoring and remote telephone service through service centre in Germany: goal is to reduce corrective maintenance • Technicians will be placed on customer site, when there is an issue they will approach it or ask for help from specialists in Germany, identify the issue, get the right parts and fix the problem • Similar in ship loaders, cement equipment, etc.	• In case corrective maintenance is required, the customer will call service centre for help • A technical assessment will take place via phone • A repair plan is made (including time line, technicians, partner companies, spare parts needed, etc.) • Repair job is conducted • Similar in wind energy
2	**Is the service response time in corrective maintenance measured already?**	• No monitoring of reponse time, only the amount of queries for maintenance	• No monitoring of reponse time	• No job based monitoring at the moment	• No monitoring of reponse time	–	• No monitoring of reponse time at the moment, but should be changed through work order documentation and generation of a service response time KPI in integrated asset management concept	• No monitoring of reponse time
2	**Are there clear structures/rules for the corrective maintenance process?**	• Australia organized in service centres, which deal with incoming queries	• Differences in regions	–	• Everything organized out of France	–	• Clear structures through integrated asset management concept and the level of agreements with customer individually on case-by-case scenarios	• Clear structures for this service centre are in place
2	**Why do break-downs occur?**	• 98-99% of break-downs occur because of bad maintenance/lack of lubrication • Wear and tear are usually no issues, part failures or engineering problems as well as incompetences in machine handling are also extremely rare	• Wear and tear are usually not an issue • Mostly part failure is responsible for break-downs, e.g. through overloading equipment, wrong/improper handling, wrong materials used, e.g. to fill into crushers)	• Skills shortage of on-site mechanics of customer and poor maintenance	• Wear and tear causes trouble as well as lack of preventive maintenance • Temparatures and vibration are big caues for break-downs • Mechanical problems cause approx. 90% of the break-downs • Operating issues, not handling the unit correctly, e.g. contermination of hydraulic systems, etc.	• The majority is due to mechanical issues	–	• Various reasons cause break-downs
2	**What are competitive objectives in corrective maintenance?**	• Quality, price, speed, safety, prevention, security	• Price, flexibility, safety, quality, dependability	• Safety, quality, speed/timeliness, flexibility	• Safety, speed/timeliness, flexibility, price, security	• Price, safety, speed, quality, dependability, security	• Price, safety, dependability, prevention	• Price, safety, dependability, prevention, speed, flexibility

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	6/1M	7/2M	8/3M	9/4M	10/5M / 10/6M	11/7M / 11/8M	12/9M
0	Business Area	Mining equpment	Mining equpment	Mining equpment	Mining equpment	Mining equpment/Mining equpment	Mining equpment	Mining equpment
0	Position	General Manager Services	Head of Global Service	Technical Service Manager	Service Manager	Head of Service & Technology/Project Manager	Commercial Manager Global Services	Head of Assembly & Coordination
0	Region	Australia	Worldwide	Sub-Saharan Africa	France/North Africa/West Africa	Worldwide/Worldwide	Worldwide	Germany
0	Years of Experience	>25 years	>20 years	>10 years	>20 years	>30 years/>5 years	>10 years	>25 years
3	**How is the service technicians' performance in corrective maintenance influenced?**	• See next points for details	• See next points for details	• See next points for details	• See next points for details	• See next points for details	• See next points for details	• See next points for details
3	**What are main factors in each process step that can be influenced operationally?**	• Accessability is an issue, especially in remote areas the technicians have to fly to get to site • Technicians need to have been to a particular site before to undergo security, drug and alcohol checks, etc.; otherwise in call out cases, these technicians cannot enter the site and unit • 4 technicians are approved for all sites • Availability of tools and spare parts is of key importance: Usually, the customer provides parts and tools out of general stock, however sometimes parts and tools need to be ordered • Identification of parts and issues is usually not an issue due to engineers on-site that operate the equipment • For electrical problems, error codes, etc. cause problems sometimes: This is the only case, where usually trouble shooting is required without 100% knowledge of the problem • Parts out of own manufacturing centres can usually be provided within reasonable times, as most crucial parts will be on stock, for other parts, temporary fixes and work arounds are needed • Technicians have to be extremely experienced to fix this large equipment, usually they therefore have worked in new installation before • All technicians have smart phones, but no other gadgets • Usually in the process of the customer calling the service centre with a rough idea of what the issue is, a repair/service cost will be discussed, so that this does not cause much interruption for the technicians on-site	• Countries without an own service centre have longer response times • Visas, customs, medical checks (e.g. units in South America in the Andean mountains) • Getting all the required (heavy) tools to the unit (hydraulic lifting equipment, etc.) can take time • Is the customer willing to pay for air freight of tools and parts (agreememnts, contracts, etc.) • Terms and conditions need to be fixed through contractual agreemements (especially liabilities in anglo-saxonian areas) • Geographical closeness to units only reasonable in cases where lots of units are under maintenance: The issue is that the costs to biuld a service centre are high, and if service is lost to the competition, a service centre in a certain area might not be needed anymore. Therefore, South African service centre services all of Sub Saharan Africa for example • Identification: History of the unit is monitored and checked - it is not allowed to modify the unit by the operator in such a way that the service provider cannot service it anymore • Electronical copy of spare parts catalog is available for technicians, customers have access to webshop and hardcopies of catalog • Oftentimes, customers have identified the issues already, therefore the reaction to the calls cannot be standardized and has to be specific to what is being asked by the customer • Operating manuals for units are available at customer site, knowledge about unit grows at customer site over time • Delivery of spare parts has low influence on service technician as customer chooses mode of transportation • Information on unit has to be available when repairing • Information exchange in briefings and meetings by technicians • In the best case, corrective maintenance is finished within 1-2 days, in the worst case it takes multiple weeks	• Emergency vehicles (pick-up trucks with trailers worth around 100,000 €) with all needed equipment is available in South Africa with reaction times of approx. 4 h (used to be around 3-4 days) • Containers with tools are also availble to be utilized immediately • Location of servie centre is key • Visas and security checks are required, customers have high influence on governments, therefore communication with customer is majorly important • Flying to site is mostly required and takes time • Knowledge about site and customer up front • Exchange of information between specialists is crucial • Catalogs • Ordering and receiving parts depend on customer wishes (air freight, etc.) and location, depending on weight, size and price of transportation as well as urgency of fixture • After trouble shooter/service technician has arrived on-site and has identified the issue, dispatching in the back office is allocated immediately (tools, parts, experts, etc.)	• With a European passport, most countries in area of operation can be accessed without visa (except Algeria and Saudi Arabia plus a few other exceptions): Here, normally somebody is equiped with a visa • Flying to site can cause delays • Safety issues are usually taken care of by the cusomter, however organization may take some time (e.g. drivers have to be confirmed, for some countries health and safety issues need to be confirmed through the company's headquarter) • Only one equipment and tooling box available, so if two or more units fail at the same time, there is a bottleneck • Diagnostic equipment is not on-site usually, reliance is on customer information • There is a lack of specialists for certain systems/more experience is required • Ordering decision proess is long (approvals of plant managers, approvals of customers, sometimes headquarter), in some countries, this is done by fax (e.g. Algeria) • Customer relationship is very important as well as relationship to other service providers (e.g. when need for spare part is given) • Deliery modes depend on weight and size as well as customer preferences, not much possibility of affecting this on the service provider side • Technicians have to be able to identify that the right parts has been delivered right away, especially with heavy equipment • Experience and knowhow are extremely important during repair (understanding the repair job, adpot to local culture and to lead a team of different mentality from a customer, competence of networking and receiving help): This is crucial and a major influence on the service response time (approx. 50%) • Communication with the customer • Availability of the right tools, high quality tools (good management and communication with subcontractors to receive these on time) • Repair plan is key, good preparation is required including the entire team	• In Europe, traveling, visas and safety checks usually are not much of an issue, however in other regions these factors matter, e.g. in Peru medical checks for work above 4,500 meters can take multiple days or weeks to acquire: Since permits are mine specific, they block the specialists for other mines, as it takes so long to get the paperwork done • To be known by the customer is very important • To become a specialist, it takes a lot of knowledge and know-how and experience (only few specialists exist worldwide) • The best possible/available technicians will be sent to site, exchange of information between technicians is highly important • Temporary fixtures are very common, if possible: However due to liabilities, the possibilities shrink • Identification of issues is handled through on-site technicians of provider up front usually: In cases, service provider needs to do the identification, this needs to be agreed contractually: Tools, e.g. endoscopes, etc. will than be brought to site as well • Tool boxes and special tools, e.g. endoscopes are centrally stored in Germany and have to be dispatched in case of needs (only limited availability), in certain key locations are additional containers with special tools, such as hydraulic equipment, stored: Depending on the region, customs are a major factor to bring the equipment in within a reasonable response time (e.g. Morocco up to 2-3 weeks of delay) • Back office is extremely important for "fire fighting" lots of details to be taken out of the way for service technicians, e.g. vaccination pass, etc. • The expecatations and requirements for service technicians are high, as circumstances are not always easy (e.g. arrival without luggage, heavy weather/climate conditions, cultural adaptations, long times away from home possible, unstable countries and regions, no telephone connections, etc.), health and safety are number one priority always • Experience is very important • Customer orientation is key in order to generate follow-up business	• Spare parts pricing is very important • Availability of data per unit is of major importance in order to give the right information to the technicians right away • Identification can take up to 2-3 weeks internally • Tools and parts need to be available on-site	• Availability of spare parts and key parts is essential • Service prices to customers are essential to get jobs • Service technicians and specialists are hard to find in the market • Experience and know-how are extremely important to handle this job (knowledge transfers have lead times of at least 2 years for new employees) • Service vehicles have to be good (jeeps to go into heavy terrain) • Secure job availability is extremely important for motivation • Language barriers with subcontractors cause issues • Support from strategic department/headquarter is very important and needs to be focussed on • Requirements for technicians are very high (traveling, security situation, flexibility, outside jobs, etc.)
3	**What are other indirect factors that can be influenced strategically?**	• Usually in the process of the customer calling the service centre with a rough idea of what the issue is, a repair/service cost will be discussed, so that this does not cause much interruption for the technicians on-site • Pricing is key (efficient and price effective service needs to be in place)	• 24/7 customer hotline for service exists • Service mindset has to be present in the organization	• Multiple failures and corrective maintenance needs at the same time can cause bottlenecks (then the network has to help out, e.g. technicians from Germany, etc.)	• Multiple jobs at the same time • Flexibility is needed as not every technician will be booked fully throughout the entire year • Cultural differences, e.g. the speed of work, language barriers, etc.	• NWC is always a topic that influences spare parts logistics • Product portolio continues to grow and gets more complex • Liability agreements are decision factors for jobs more and more often • Multiple jobs in different regions (e.g. Zambia and India) simultaneously	• OEE has a new method/incentive of internally reducing response times	• Customer gains more and more control over the own equipment and can service it without service providers
3	**What are factors that cannot be influenced?**	• Environmental reasons such as cyclones in the summer months	• Geographical locations are sometimes challanging • Weather conditions, e.g. Canada during winter with lots of snow and ice	• Weather is not an issue usually	• No weather issues	• Infrastructure is important (e.g. Germany different than Indonesia) • Geographical location plays a significant role	–	• The weather has an influence on the maintenance cycles, e.g. in winter more cole is needed to generate energy for the cities in the core-plant, therefore most planned maintenace will take place in the summer • Vacation and sick days

Topic	Main Questions and Sub Questions	Inputs from Interviewees						
0	Interview/Interviewee per BA	6/1M	7/2M	8/3M	9/4M	10/5M / 10/6M	11/7M / 11/8M	12/9M
0	Business Area	Mining equpment	Mining equpment	Mining equpment	Mining equpment	Mining equpment/Mining equpment	Mining equpment	Mining equpment
0	Position	General Manager Services	Head of Global Service	Technical Service Manager	Service Manager	Head of Service & Technology/Project Manager	Commercial Manager Global Services	Head of Assembly & Coordination
0	Region	Australia	Worldwide	Sub-Saharan Africa	France/North Africa/West Africa	Worldwide/Worldwide	Worldwide	Germany
0	Years of Experience	>25 years	>20 years	>10 years	>20 years	>30 years/>5 years	>10 years	>25 years
4	**How might the negative impacts on the service technicians' performance in corrective maintenance be overcome?**	• Be close to site/set up regional hubs • Set up regular visits in order to assure closeness and knowledge about the site, equipment and customer • Have a minimum number of technicians approved for all sites • Temporary fixes and support of other customer by lending parts • At the moment an app is under construction to ease up communication with customers	• Fast track in service: In new installation, three different offers have to be generated and compared, this is not possible in corrective maintenance due to the urgency of the needs • Supplier relationships have to be focussed on in order to find trustworthy suppliers with minimum lead times • A certain amount of employees always fulfill the needed requirements (e.g. 2-3 people with valid visa and medical checks for Saudi Arabia) • A critical mass/volume of service is needed in order to successfully offer service worldwide • Parts planned/built for new equipment needs to be available for the use as a spare part in emergencies - prioritization • Service technicians have to be present on-site • Different levels of service technicians/expert structures have to be implemented and filled through training programs • Oftentimes, customer technicians are much better informed about the units than the service provider's technicians - learn from them	• Emergency vehicles in all major hubs • 2-3 people with visas for all areas of operation at all times • Customer relationships are of major importance • For every new customer, research and preparation needs to be done (send somebody to site, collect GPS data, travel plans, info on the equipment, health and safety issues, logistics options, accomodations close to site, measurements of traveling time (e.g. West Africa up to 48h), etc.): This needs to be know up front to be prepared when something breaks down • Trip planning is done by back office • To identify issues right away, communication and remote help up front through the telephone call are extremely important • Additionally, here it can be identified, whether or not specialists have to be sent to site (electrician, software specialist). This needs to be clear to fix the problem with the first trip to site. • Whatsapp groups with specialists and customer help solving issues • Mobile devices to troubleshoot right away • Lessons learned after job has been finished need to be captured • Remote monitoring of unit could help in the future (e.g. access to external customer computer system in order to check historical data, monitor bearing temperatures, etc.) • Tablets for communication and working including software to get rid of paperwork • Managing the morale of the technicians is very important (tough working conditions, good food, health, sleep, accomodation, etc. need to be taken care of, feedback during the day, constant support, working hours need to be monitored): Satisfied technicians are the best way of reponding to customer needs quickly, unhappy technicians get frustrated and demotivated or hurt in the worst case)	• Remote services and advising are extremely important • Two passports are advantageous • Closeness to site makes sense, if there is enough business to build a branch office • Customs and availability issues of equipment and tooling boxes (each about 30 kilos and 50.000 € worth) can be eliminated by strategically locating multiple of these in different regions • Training on multiple different equipments is necessary to cover market and react to potential of service in this area of operation • Focus on customer and inter-company relationships • Communication skills • Adaptation to other cultures and working habits (training/preparation), possibility of learning language • A lot of travel/personal issues of the technicians have to be handled by the company • Motivation and work-life-balance (money, family time) are extremely important to keep in mind	• Contractual details and liabilities need to be clarified up front and by the back office to not interfere with technical clarification by technicians • Know-how for highly complex equipment needed • In special markets or regions, service employees need to be present and close to the customers at all times • Focus on liabilities strategically • Strong back office is important to take care of details so that service technicians do not have to deal with them and can focus on their work • Preparatory training for technicians before they go on assignments could be improved • High flexibility is important to focus on for service technicians • Customer orientation training is very important • Make better use of customer feedback	• Integrated asset management concept as a new lever to generate more margins in service and give more control on maintenance to service provider, thus reducing response time • Data availability for every unit under maintenance in order to identify issues and parts easily • Make use of generated knowledge and add to history through documentation of work in work orders in system • Place technicians on-site for immediate response and have experts/specialists available in know-how centres (cement, mining, shiploaders, etc. in different locations) for worldwide dispatching • OEE as incentive for quick response times	• Secure availability of parts and tools • Preventive systems to eliminate failures • New concepts are required for service business • Motivate techicians (e.g. through jobs in other locations, etc.) • Communication between operational and strategic departments is to be improved

Appendix 6: Summary of key points/highlights from the IT hardware business area interviews

Topic	Main Questions and Sub Questions	Inputs from Interviewees			
0	Interview/Interviewee per BA	14/1I	15/2I	16/3I	17/4I
0	Business Area	IT hardware	IT hardware	IT hardware	IT hardware
0	Position	Senior Consultant CRM-Service-Logistics	Service Director Germany	Service Manager	Post Sales Supply Chain Manager Central Region
0	Region	Worldwide	Germany	Germany	Germany/Austria/Switzerland/BeNeLux
0	Years of Experience	>35 years	>25 years	>25 years	>30 years
1	**How important is spare parts logistics in general for your company?**	• High correlation between repurchase of equipment and loyalty only in cases of high customer satisfaction - customer relationship management is extremely important • As technician is the face to the customer, he/she plays a crucial role and has major influence on the service processes, and thus the chance to generate additional business • Logistics, and especially the service technician can be the differentiator between competitors	• Maintenance and spare parts sales as a major part of the business model • High customer satisfaction is of major importance • Increasing competition	• In today's business environment, everything needs to be qiucker and on time: logistics is a key trigger to satisfy this demand and a chance to differentiate from the competition	• Trend goes from product-driven industry to a solution-driven industry: services such as archiving, maintenance, etc. become increasingly more important for companies and therefore also service providers • Logistics and service logistics are the supply pipe for successful operations • Overall highly important
1	**How important is corrective maintenance in spare parts logistics in your company?**	• Quick and high quality service is the differentiator when it comes to customer satisfaction, especially when equipment fails • Failing equipment in this business area can cost the operator a lot of money: this varies depending on the product and the exact context of the business, but generally up to multiple thousands of Euros per day of production loss (laptops have to operate in order for employees to fulfill their business, printers as well, especially in production settings) • High penalties are the consequence for non-compliance with service level agreements in cases of corrective maintenance	• Maintenance is key business in banking IT • Availability of equipment is key performance indicator (365 days * 24 h - downtimes) • 95% of all recycle machines, e.g. ATMs (cash-in/cash-out) and 98% of all non-cash equipment (printer for bank statements, etc.) have service contracts in Germany • Banks earn money especially with transactions on third-party equipment (e.g. customer from bank A collects money from bank B): if an ATM does not work, this causes losses • Low density of ATMs in rural areas means that if the available ATMs are out of order, banks earn less money and customers are very dissatisfied • ATMs are face to the customer: every out of order ATM is reported to the management board usually • Safety features are very high, therefore maintenance is extremely important (e.g. under every ATM there is a safe)	• Service only works with efficient and high quality processes • Service is a major margin generator and one of the main focus areas therefore • 99% of all printers in business settings have service contracts • Focus is on corrective maintenance (break-fix-concept) rather than preventive maintenance, however high-frequency service items are serviced based on calculated operating/break-down cycles • Uptime and customer satisfaction are key factors and have high priority • Even with parallely operating equipment, uptime is very important, especially in production settings (production losses can go up to multiple mio. Euros)	• To differentiate one's service, high quality and quick service is extremely important, especially when equipment fails • Especially in production settings, where orders are tacted in narrow slots, a failing printer causes high production losses: quick repairs are therefore extremely important to guarantee high operating times (e.g. insurance companies sometimes have service level agreements up to 100%, as when invoices are sent late, this automatically means later payments) • Not only in production settings, but also with small printers (e.g. of board members or politicians in offices), equipment failure needs to be reacted to immediately • Back-up equipment is usually provided for important equipment and customers: however even here quick response times are required in order to recreate the guarantee of a back-up quickly • Even catridges are oftentimes exchanged by service technicians even though the customers are easily able to do it themselves: however in settings, where a lot of printers are operating in large production facilities, customers oftentimes want to receive full service out of one hand and not deal with the risk of production loss, etc. - this is therefore shifted to the service provider for a fee • Overall highly important
1	**Please explain the context of your spare parts logistics corrective maintenance business.**	• Various industries within the business area, ranging from laptops to printers (desktop and production) as well as banking IT, etc. • Minor variations in different sub-business areas, however the general ideas and processes are the same everywhere in IT hardware after-sales service • In IT overall, but especially in laptops and desktop computers industries, remote assistance plays a signifcant role in corrective maintenance, as spare parts portfolio is not as big as in other industries • Service on own and third-party products possible • Multiple levels of service available for customer to choose from (full service maintenance agreement, technical assistance included and only spare parts have to be paid, material contract and only technician service has to be paid, bring-in services, pick-up services, like-for-like exchanges (leasing, exchange)): warranty - high focus on level 1 & 2 support • Not every product will be serviced at site, e.g. small printers, laptops, etc., which are sent in to a repair centre much rather	• Out of 240 employees, 155 are in service • Approx. 360 banks as customers for this service provider • Third-party maintenance possible • Two main types of contracts exist usually: to be at site within 4 h; to have the equipment fixed within 6 h (service response time) - trend goes to second type of contract for higher customer satisfaction: some customers also have both contracts (more expensive); next business day repairs are also available • Technicians have car stocks, which are controlled by an automatic replenishment tool that calculates the stock utilization every half year: secures availability of 90% of the needed parts • In Germany, six regional warehouses are in place to secure availability of the missing 10% of needed parts as well as central warehouses in Northern and Western Germany (Wedemark and Koblenz) for very rare parts • In extremely rare cases, full functioning equipment is on stock, which can also be used as spare parts supply units • Approx. 80 pickpoints are available in Germany, especially for urgent parts or larger parts • Every unit is calculated to fail approx. three times per year and to provide approx. 25 € of maintenance revenue to the service provider • Standard parts can cost up to approx. 2,000 € • Banking specialty to consider versus printing, etc.: extremely high security legislations apply according to Europen Union, European Central Bank, etc. with regards to software, return processes of used equipment, availability of security personnel of the bank, etc. • Overall approx. 68,000 ATMs in Germany (plus other banking IT equipment), with rather low density in rural areas of Bavaria or Brandenburg and high density in big cities	• Company with approx. 115,000 employees worldwide, one of the major players in printing systems • Service for all sorts of printers, from desktop printers to production printers (two focus areas: production printing and office printing) • In Germany, one branch office in Neuss stears the service • Spare parts portfolio largely consists out of rather small parts, however bigger parts are also available: the trend goes towards modules, which then are heavier and bigger • Calculations for each part are made to see how often it fails on average per 1 mio. prints: this is done to identify the parts that need to be focussed on and to create van kits • Service mainly on own equipment, however also possible on third-party equipment • Approx. two calls per day per service technician for corrective maintenance • Core service time from 8 - 17 o'clock, during the rest of the time emergency services are available: trend towards need for emergencies rises, especially in bigger companies, therefore additional technicians and service times are offered, for instance for insurances • Parts can cost anything between Cents and approx. 10,000 Euros, average parts cost around 100 Euros • Printing is seasonal (e.g. in insurances, photo book printing, etc.) • Response time on average 2 h to be at site, then fixing the issue: in harder cases this can last 1.5-4 h, e.g. with loose contacts, etc. - sometimes it can even take days, but also only very few minutes to fix an issue)	• Recent development goes towards customer enabling through remote help directly on the phone, module-based and easy to exchange-spare parts (design-optimization), the service technician remains the last authority in the process whenever high quality is required or complex errors occur • Technicians have car stocks, can order remaining parts from central ware house overnight or make use of spare parts depots at customer site for ad-hoc service • Differentiation between consumables (ink, etc.) and spare pars • Selling solutions, service level agreements, back-up equipment, spare parts at customer site and on site employees merge for a full (corrective) maintenance and service package • The idea is to not have a certain service technician service a certain printer, much rather oftentimes in urgencies, spare parts are sent directly to the customer or close-by PUDOs for the nearest technician to pick it up and repair the unit directly • Different support levels can be escalated flexibly • Strong focus on operational doability rather than theoretical trial and error • One central European warehouse that supports a major part of the worldwide network, other than that only small warehouses in Europe besides car stocks, customer stock and pickpoints • Overall approx. 60,000 different parts and consumbles available • Parts range from small parts, e.g. screws, to parts that need to be delivered on palettes

Topic	Main Questions and Sub Questions	Inputs from Interviewees			
0	Interview/Interviewee per BA	14/1I	15/2I	16/3I	17/4I
0	Business Area	IT hardware	IT hardware	IT hardware	IT hardware
0	Position	Senior Consultant CRM-Service-Logistics	Service Director Germany	Service Manager	Post Sales Supply Chain Manager Central Region
0	Region	Worldwide	Germany	Germany	Germany/Austria/Switzerland/BeNeLux
0	Years of Experience	>35 years	>25 years	>25 years	>30 years
2	**How does the spare parts corrective maintenance process look like in your everyday work?**	• Customer calls • Validation of customer through service centre • Remote assistance, whenever possible (especially in laptops industry): For remote help, the service centre/back office has all available units under maintenance (laptops, printers, banking IT equipment) on stock for stepwise and realtime error analysis on real equipment) • Another remote assistance possibility is to intrude on the broken unit through cloud/internet solutions • If remote assistance is not successful, service technician is dispatched to drive to the unit • In 95-97% of the cases, the error/broken part can be identified through remote assistance • If part needs to be exchanged through service technician, the part will be delivered overnight into a drop box, PUDO, into the service technician's car, or to customer site directly • Express services are available • Availability of spare parts is secured through multiple layer network of stocks (van kits, satellite storages, central warehouse, suppliers with quick replenishment times): Also colleagues can be approached • Service technician repairs unit • Service technician can approach customer with the knowledge that he/she will be able to fix the equipment in the first approach through the previous work and information flow during the remote assistance process • Similar in gas thermes, coffee and vending machines	• Standard process: call; remote assistance; dispatch of technician; drive to unit; identification, if necessary; order part/use part from car stock; exchange of part • Service technicians should be very experienced and have high general knowledge (fluctuation in this industry only at approx. 1%, therefore high learning curve effects possible) • Specialization possible • Service technician has approx. 120 units under maintenance, if service level agreement states next business day repair, approx. 100 units with 6h fix service level agreement, and approx. 80 units when focussing on 4h service level agreements • As technicians have fixed set of units under maintenance, automatic dispatching is done through software (this software also shows, which units need service and calculates, if this is possible for one technician - if not, automatic dispatch of back-ups three times, then manual dispatching, if all three back-ups are unable to provide service) • Technicians use car stock or order from regional stocks, which can then be picked up or delivered to PUDOs, car stock, customer, etc. • Service can only be done with safety personnel of the bank, as high amounts of money are involved: for every maintenance process, an agreement with the safety personnel has to be arranged on the timing and availability • Similar in printing, PCs and networks	• Customer calls central service number and reaches welcome centre (95% qualified service technicians) for remote assistance (as-is: 12 to 15%, goal: 20 to 22%) • Disposition of service technician is software based (geographical location of unit, response time/service level agreement, qualification of technician required, special requirements with regards to safety or alike, office hours, driving times, lunch breaks, etc. are all influencing the choice/disposition of technician): no fixed portfolio per technician, technicians are trained on every product separately • Service technician is informed on his smartphone through an app and has all necessary information available (customer information, unit information, telephone numbers, etc.) • Service technician accepts/rejects call: with acceptance, he/she documents travel time and reports when he is at site (for service response time calculations) • Classical identification of issue (optical identification, use of diagnostic tools, electronical documentation, etc.) • Service technician has portfolio of parts in car stock and can handle approx. 95% of all issues the first time with this parts portfolio (incl. cleaning, resetting, operator issues, etc.), approx. 15% of parts are not in car stocks and need to be ordered from central European warehouse or satellites • If part is not in car stock, it can be ordered through mobile device app (the app knows the car stock inventory, bookings can be done through scanning with the mobile phone and then an automated replenishment process of the car stock is initiated) • Customer stock can also be booked through app and is replenished automatically • Delivery of parts at pickpoints or directly into the service technicians' cars overnight or expressed right away (3-4 h from central warehouse) in urgent cases, otherwise regular replenishment once or twice a week • Delivery of parts at pickpoints or directly into the service technicians' cars overnight or expressed right away in urgent cases, otherwise regular replenishment once or twice a week • Express orders have to be authorized • Repair of unit • Similar in car windows and many other businesses	• Customer calls in welcome centre or automatic notifications are given from printers to service operators regarding need for service/repair • Remote diagnosis has a high focus in order to fix issues right away and create high availability for customer equipment • In some cases, diagnosis and parts identification is necessary on-site, the service fitter tries to inform him- or herself about the error codes and possible reasons for failure beforehand however whenever possible • For consumables, these are usually directly sent to the customers: the customers are enabled to exchange consumables themselves • For consumables automatic replenishment processes are usually installed, in urgent cases emergency deliveries can always be organized quickly • For spare parts, sometimes the customers are able to exchange some parts as well: they are then provided with the necessary spare parts the day after ordering, in urgent cases emergency deliveries are possible as well • In regular cases, parts are either delivered overnight to service technicians (car, PUDO, etc.) in urgent cases or the car stocks are replenished regularly after consumption • Maintenance is then scheduled and conducted based on urgency and service level agreement • Similar in automotive
2	**Is the service response time in corrective maintenance measured already?**	• Yes	• Yes, in accordance to the types of contracts/service level agreements (be at site within 4 h; have the unit fixed within 6 h, next business day), analyses can be made by week, by month, etc.: also, this is helpful for modern service level management, e.g. why should the provider have 100% service level fulfillment with one customer, if this customer only pays for 95% service level fulfillment	• Yes, however only call - arrival at site is measured, fix time is excluded as it is extremely difficult to calculate	• Response times depend on service level agreements and urgency
2	**Are there clear structures/rules for the corrective maintenance process?**	• Yes	• Yes, in Germany	• Yes	• Minor regional differences depending on service level agreements and regional circumstances, however the global approach is stringent in general
2	**Why do break-downs occur?**	• Usually wear and tear • Operator misusage causes issues	• Mechanical and electronical issues • Broken monitors are highly frequent issues due to violence • Wear and tear	• Mechanical and electronical issues • Operator misusage on larger printers	• Usually mechanical or electro-mechanical and electronical issues are the main reasons • Improper operator handling is usually not an issue
2	**What are competitive objectives in corrective maintenance?**	• Timeliness, flexibility, quality, price, dependability, prevention	• Timeliness, flexibility, quality, price, dependability, prevention, security	• Flexibility, quality, price, dependability, safety, speed	• Safety, quality, dependability, speed

Topic	Main Questions and Sub Questions	Inputs from Interviewees			
0	Interview/Interviewee per BA	14/1I	15/2I	16/3I	17/4I
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0	Position	Senior Consultant CRM-Service-Logistics	Service Director Germany	Service Manager	Post Sales Supply Chain Manager Central Region
0	Region	Worldwide	Germany	Germany	Germany/Austria/Switzerland/BeNeLux
0	Years of Experience	>35 years	>25 years	>25 years	>30 years
3	**How is the service technicians' performance in corrective maintenance influenced?**	• See next points for details	• See next points for details	• See next points for details	• See next points for details
3	**What are main factors in each process step that can be influenced operationally?**	• Information received through different support levels, especially during remote assistance • Proximity and quality of stock of satellite stocks • Catalogs have less of an influence, as manuals are available on mobile devices: In case of multi-device providers, catalogs are more important, especially on mobile devices • Closeness to site (e.g. permanent technicians, for instance, at airports are usually quicker than technicians that need to drive over distances to reach a site) • Low amount of units in certain areas, e.g. islands • Availability of spare parts, diagnostic equipment and tools is very important • Availability of service manuals • Expected mean time between failure for equipment or certain parts • Training, knowledge and experience • Knowledge about new equipment and respective spare parts after product launches • Van kits • Mobile device is key to success (includes information on the job, etc., paperless working environment, approvals can be done right away and electronically, GPS available, spare parts ordering can be done, manuals for all equipment are available, automatic replenishment of utilized car stock spare parts initiated when parts are booked, last issues per unit, stock availability of all car stocks can be seen, etc.)	• Availability of bank's safety personnel, which is always required, can cause delays and sometimes costs high efforts to be arranged • Mobile devices are available • Technician knows customer and units as he/she has fixed portfolio of units under maintenance • Worst case scenarios usually include not identifying the issue: then second level support needs to be included, machine data needs to be analyzed through diagnostic tools or software in the back office, key specialists can be contacted, or a full exchange of the unit with a back-up needs to be arranged • Remote assistance only possible, if allowed through banks and safety personnel • High influence of identification: can customer name issue already or does it need to be solved through the technician at site • Drive to unit can cause delays, especially, if a part needs to be picked up at a pickpoint, etc. • Delays are caused, if a special technician is required, who is unavailable however • A call has to be reacted to, meaning planned for service, within one hour • Availability of right parts and tools in car stock • The service technician is the key factor in the corrective maintenance process	• Data security can be a factor, as it is extremely important for certain businesses, e.g. insurances • Repair usually costs most time • Driving to unit costs a lot of time • Remote service or information gathering reduced reponse times • Identification is important, but a bit less of an issue • Availability of the right parts and tools in the car stock • Knowledge and experience	• Availability of parts at the right time at the right place is critical • Quick error identification and parts recognition are extremely critical in order to be able to achieve first time fixes and quick response times therefore • Information acquired remotely helps a lot: experts in the back office/welcome centre are extremely important • Knowledge and experience level of the service technicals are critical • Driving to the units directly may cause delays in response time • Knowledge and experience level of the service organisation is critical
3	**What are other indirect factors that can be influenced strategically?**	• Service capacity of a company (number of calls/jobs per hour/day, etc.) • Not enough qualified technicians for the amount of work • Service level agreements and response time goals • Availability on the weekends/holidays	• Manpower • Amount of units under maintenance	• Car stock • Strategic decision: How good does our equipment need to be? Do we want to produce equipment that never fails?	• Car stock • Service technician is face to the customer: mindset must be present
3	**What are factors that cannot be influenced?**	• Traffic jams, weather, etc.: usually only have a very marginal influence • Customers and other circumstances	• No issues	• Large buildings and factories with spread units	• No issues

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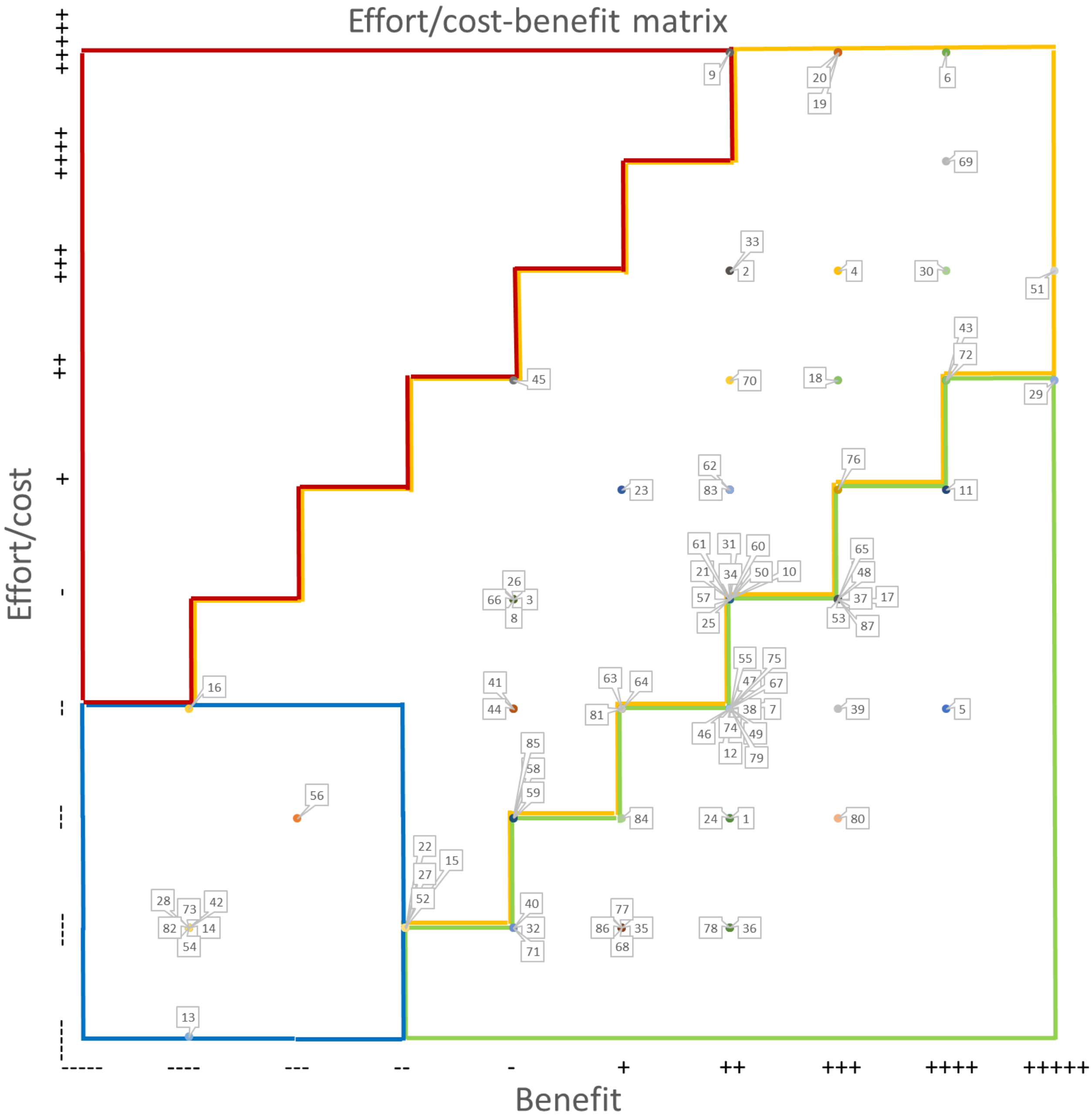
0	Position	Senior Consultant CRM-Service-Logistics	Service Director Germany	Service Manager	Post Sales Supply Chain Manager Central Region
0	Region	Worldwide	Germany	Germany	Germany/Austria/Switzerland/BeNeLux
0	Years of Experience	>35 years	>25 years	>25 years	>30 years
4	**How might the negative impacts on the service technicians' performance in corrective maintenance be overcome?**	• Service technician has to be part of the solution, not part of the problem: he/she needs to be enabled to fix the issues in corrective maintenance with the first approach: customer orientation must be the top priority • Make use of customer feedback • Mobile device roll out and further push including further input from operational and strategic viewpoints • Use of alternative products that can be used in case another part is not quickly available are stored centrally • Smart equipment, e.g. large printers or newer computers have error storage to be directly transferred to diagnostic tools of service technicians • Product designers and engineers have to make sure that parts, especially consumbles, etc. can be exchanged easily and quickly: Possibility of parts to be exchanged by customers themselves is of key importance for qiuck response time • Optimization of repair centre • Create single point of contact for customers • Due to the importance remote assistance and service, highly skilled and experienced technicians should do this job • Portfolio of parts (in stock, van kits, etc.) has to be updated regularly and dealt with flexibly (core portfolio in each van kit and additional stock based on units under maintenance of each technician, e.g. small or big printers, etc.) • Optimized replenishment of stock within the different levels of stock locations • Avoid multiple drives to unit (first time fixes) especially in remote areas • React to language barriers through training • Keep in mind Industry 4.0 (technical assistance), 3D-printing, cloudsystems, sensors and other technical developments and trends • Balance between geographical/routing optimization and knowledge/experience level of service technicians is very important to send the right person to the right site quickly	• Low fluctuation (learning curve effects): set incentives, e.g. allow for specialization • Fixed set of units in each technician's portfolio (technician knows units and customers, knows best pickpoints to collect ordered spare parts, easy dispatching with back-up technicians available, etc.) • Dispatch software which shows need for service, availability, etc. • Full exchange of unit through back-ups • Focus on modules to be exchanged and repaired rather than single spare parts • Good communication and trust levels need to be generated in order to get remote access or quick slots for safety personnel availability • Animate technicians to use their customer connections to call them back and pre-identify the issue remotely • Availability of car stock according to each technician's needs • If possible, use data per technician to analyze optimization potential (three core areas with equal influence: product know-how (easy to learn); soft skills (customer management, planning and interaction, representation of the company, self-organization, etc.); administration (documentation, bookings, analysis skills, utilization of spare parts according to the processes, etc.): technicians and service providers are easily exchangable, therefore these focus areas are of key importance • Additional data points that can be collected per technician include sick days, number of units serviced, amount of revenues generated, etc.: the technicians are trained and schooled for these KPI and target achievements should be clear; if a target is not fulfilled, trainings and conversations, e.g. to discuss tooling requirements or other optimization potential identified by the technician, should help to align strategic and operational goals	• Module solutions • Measurement of how often a part/module, etc. breaks per 1 mio. prints to caclulate the number of service technicians required • Communication and customer relationship management are key to success • Increased focus on remote service: low resources, no waiting times for customer, immediate satisfaction • Further optimize disposition software based on technicians' feedback • Eliminate having to go to a unit twice (first time fixes) through routing software and increased effort in remote services and information gathering • Automatic replenishment implemented • Further optimization of car stock portfolios • Use knowledge of service technicians more for further optimizations • Train and qualify technicians, especially to react to trends (electronically operating printers with lots of software rather than mechanical printers) • Knowledge data base, which includes tips and tricks with a ranking on usability, etc. and searching functions for colleagues • More preventive systems inside the units • Cloud solutions to fix software bugs, etc. remotely • Use of internal Twitter-like communication platforms for quick exchange of ideas and needs, which can all be handled through the mobile phones that each service technician has • Optimize equipment failure calculations and predictions	• Smart and flexible couriers in accordance with service level and urgency • Foucs on remote call assistance in order to solve issues directly and/or to better support technicians with the right information, spare parts, etc. • Enable key operators • Back-up equipment portfolio to give service technicians time to fix issues in highly important production settings, etc. • Concept of every technician being able to service various types of unit (in escalation levels) in order to send parts to customer/nearby PUDO for the next available and closest-by service technician to fix the equipment • Preventive concepts, such as mean time between failure proximations, etc. • Design more module-based spare parts for easy exchange • High performance software with which the service technicians have all necessary information and documentation, catalogs and options to order, etc. on their mobile device ("call scheduling software") • Training matrices with clear structure to train the servie technicians continuously • Bind service technicians and create low fluctuation in order to make use of high experience levels • Link service technicians' profiles to scheduling and dispatching to send the most suited and best available service technician to each job • Emphasize on early ordering to activate overnight delivery on time • Make use of the ideal call instruction to retrieve all necessary information from incoming customer calls for service

Appendix 7: Effort/cost-benefit matrix for the 87 identified solutions to improve service technicians' response time in corrective maintenance for stationary equipment (conservative)



Appendix 8: Ratings and recommendations per solution/improvement opportunity (conservative)

Solution Number	Solutions/ improvement possibilities	Must criteria			Effort/cost of solution	Benefit of solution	Recommen-dation for action (conservative)
		Legal	Safe	...			
1	Smart questioning manuals/instructions, e.g. perfect call descriptions	y	y	...	---	++	Implementation should be pursued
2	Service centre trainings	y	y	...	+++	++	Closer examination/strategic decision
3	Back-up equipment of certain units/parts to support in error identification remotely	y	y	...	-	-	Closer examination/strategic decision
4	Increase remote service/assistance focus	y	y	...	+++	+++	Closer examination/strategic decision
5	Install experienced technicians in remote positions	y	y	...	--	++++	Implementation should be pursued
6	Sensors/preventive software/systems with error possibility notifications	y	y	...	+++++	++++	Closer examination/strategic decision
7	Flexible concepts for area of operation, e.g. motor taxis, public transport, service bus, permanent technicians, etc.	y	y	...	--	++	Implementation should be pursued
8	Visit new customers/units to retrieve all necessary information	y	y	...	-	-	Closer examination/strategic decision
9	Service centres in close proximity to major service markets	y	y	...	+++++	++	Implementation not recommended momentarily
10	Geo-tracking	y	y	...	-	++	Closer examination/strategic decision
11	Software based dispatching based on factors such as knowledge, qualification, urgency, availability, out-of-office times, location of unit, location of technician, etc.	y	y	...	+	++++	Implementation should be pursued
12	Information on customer, unit, work around solutions/alternatives/tips in a knowledge database electronically available on mobile device	y	y	...	--	++	Implementation should be pursued
13	Back-up system to secure at least three to four technicans having the necessary permits to access a certain site	y	y	...	-----	----	Quick hit
14	Two passports per service technician, if necessary	y	y	...	----	----	Quick hit
15	Navigation system/GPS in every car	y	y	...	----	--	Closer examination/strategic decision
16	Language/intercultural trainings	y	y	...	--	----	Closer examination/strategic decision
17	High quality diagnostic tools	y	y	...	-	+++	Implementation should be pursued
18	Third-party equipment diagnostic tools	y	y	...	++	+++	Closer examination/strategic decision
19	Image recognition software for mobile devices (such as Google glasses)	y	y	...	+++++	+++	Closer examination/strategic decision
20	Augmented reality applications, that show information on parts/units	y	y	...	+++++	+++	Closer examination/strategic decision
21	RFID/Scanning functions on mobile devices	y	y	...	-	++	Closer examination/strategic decision
22	Install KPIs on how often certain parts fail, e.g. mean time between failure, etc.	y	y	...	----	--	Closer examination/strategic decision
23	Access units remotely through clouds	y	y	...	+	+	Closer examination/strategic decision
24	Online/electronical spare parts catalogs/manuals available on mobile devices	y	y	...	---	++	Implementation should be pursued
25	Unique parts numbers, descriptions, dimensions and other information included in catalog on mobile devices	y	y	...	-	++	Closer examination/strategic decision
26	3D-drawings/explosion drawings were necessary in catalog on mobile devices	y	y	...	-	-	Closer examination/strategic decision
27	Multiple pictures from various angles per spare part in catalog on mobile devices	y	y	...	----	--	Closer examination/strategic decision
28	Regular updates of catalog on mobile devices	y	y	...	----	----	Quick hit
29	Mobile device for every service technician	y	y	...	++	+++++	Implementation should be pursued
30	Strong IT-/ERP-support	y	y	...	+++	++++	Closer examination/strategic decision
31	Unique parts numbers that match with information in catalog on mobile devices	y	y	...	-	++	Closer examination/strategic decision
32	Additional information on spare parts that matches with information in catalog on mobile devices	y	y	...	----	-	Implementation should be pursued
33	RFID/Scanning functions on spare parts	y	y	...	+++	++	Closer examination/strategic decision
34	Bill of matierial per unit	y	y	...	-	++	Closer examination/strategic decision
35	Easy exchange of information and pictures in chat functions on mobile devices	y	y	...	----	+	Implementation should be pursued
36	Different technicians/support levels for different issues	y	y	...	----	++	Implementation should be pursued
37	Specialization trainings	y	y	...	-	+++	Implementation should be pursued
38	Regular technical trainings (knowledge building and refreshments)	y	y	...	--	++	Implementation should be pursued
39	Customer management/orientation trainings	y	y	...	--	+++	Implementation should be pursued
40	Paperless approvals through mobile devices	y	y	...	----	-	Implementation should be pursued
41	Install fast track ordering process in urgent cases, where usually, due to the price of the spare parts, three offers would be needed	y	y	...	--	-	Closer examination/strategic decision
42	Clear approval processes/structures implemented	y	y	...	----	----	Quick hit
43	Automatic car stock replenishment through mobile device bookings/statistics	y	y	...	++	++++	Closer examination/strategic decision
44	Optimized portfolio based on region, units under maintenance, individual needs, etc. with regular updates	y	y	...	--	-	Closer examination/strategic decision
45	Automatic stock location replenishment through software	y	y	...	++	-	Closer examination/strategic decision

...

...

46	Mobile device should show nearest available stock location for each part	y	y	...	--	++	Implementation should be pursued
47	In emergencies, make use of parts produced for new installations (manufacturing centres)	y	y	...	--	++	Implementation should be pursued
48	Web shop for direct ordering via mobile device	y	y	...	-	+++	Implementation should be pursued
49	Information on re-order times, availability of parts, nearest stock locations, etc. on mobile device	y	y	...	--	++	Implementation should be pursued
50	Paperless orders/bookings through RFID/scanning functions on mobile device	y	y	...	-	++	Closer examination/strategic decision
51	3D-printing	y	y	...	+++	+++++	Closer examination/strategic decision
52	Clear identification/diagnosis processes	y	y	...	----	--	Closer examination/strategic decision
53	Supplier relationship management for a network with quick delivery times	y	y	...	-	+++	Implementation should be pursued
54	Allowing local purchases with easy processes in situations, where other options are not as good	y	y	...	----	----	Quick hit
55	Create a flexible delivery concept with multiple options for the technicians/customers to pick from	y	y	...	--	++	Implementation should be pursued
56	Possibility to pick up parts at warehouse, if necessary, and pre-notification through mobile devices	y	y	...	---	---	Quick hit
57	Possibility to have parts delivered to pick points/PUDOs through mobile devices	y	y	...	-	++	Closer examination/strategic decision
58	Reliable forwarders	y	y	...	---	-	Closer examination/strategic decision
59	Forwarders with extensive network of pickpoints/PUDOs	y	y	...	---	-	Closer examination/strategic decision
60	Possibility to have parts delivered into cars/vans/trucks through mobile devices	y	y	...	-	++	Closer examination/strategic decision
61	Possibility to have parts delivered to site through mobile devices	y	y	...	-	++	Closer examination/strategic decision
62	Possibility to have parts delivered directly, e.g. through emergency transports specifically hired therefore, e.g. pensioners, through mobile devices	y	y	...	+	++	Closer examination/strategic decision
63	Repair kits with standard tools	y	y	...	--	+	Closer examination/strategic decision
64	Repair kits with standard parts for certain issues	y	y	...	--	+	Closer examination/strategic decision
65	High quality and light tools	y	y	...	-	+++	Implementation should be pursued
66	If necessary and possible, exchange entire units or modules for quick response time, error identification and re-exchange are to be organized in the back office	y	y	...	-	-	Closer examination/strategic decision
67	Information on terms/conditions/liabilities/service level agreements/contractual agreements available on mobile device	y	y	...	--	++	Implementation should be pursued
68	Agreements should be dealt with by back office and not affect service technician	y	y	...	----	+	Implementation should be pursued
69	Design platform based units to reduce the number of parts	y	y	...	++++	++++	Closer examination/strategic decision
70	Design module based solutions	y	y	...	++	++	Closer examination/strategic decision
71	Utilize/hire service technicians from other business areas	y	y	...	----	-	Implementation should be pursued
72	Monitor service technicians performance (where possible) in order to point out improvement opportunities	y	y	...	++	++++	Closer examination/strategic decision
73	Mirror training needs with actual trainings received regularly	y	y	...	----	----	Quick hit
74	Administrative trainings	y	y	...	--	++	Implementation should be pursued
75	Softskill trainings	y	y	...	--	++	Implementation should be pursued
76	Incentivize technicians	y	y	...	+	+++	Closer examination/strategic decision
77	Beware of technicians' needs	y	y	...	----	+	Implementation should be pursued
78	Incorporate technicians' knowledge	y	y	...	----	++	Implementation should be pursued
79	Motivate technicians through trainings, etc.	y	y	...	--	++	Implementation should be pursued
80	Safety focus, e.g. through dead-man-function	y	y	...	---	+++	Implementation should be pursued
81	Install emergency service for out-of-office times according to service level agreements	y	y	...	--	+	Closer examination/strategic decision
82	Install globally used KPI to measure service response time	y	y	...	----	----	Quick hit
83	Create awareness that a certain level of parts availability is required in order to allow for quick response times (thus possibly causing higher networking capital)	y	y	...	+	++	Closer examination/strategic decision
84	Allow for structured exchange of ideas between technicians as well as between technicians and strategic management, e.g. regular meetings	y	y	...	---	+	Implementation should be pursued
85	Communicate new products/production stops to after-sales service department structured and well in advance	y	y	...	---	-	Closer examination/strategic decision
86	Make use of and monitor customer feedback	y	y	...	----	+	Implementation should be pursued
87	New concepts, such as integrated asset management, new technological developments, etc. should always be considered and challanged regularly	y	y	...	-	+++	Implementation should be pursued