Tampereen yliopisto

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ESTABLISHING PREDICTIVE MAINTENANCE BUSINESS IN A FURNITURE MANUFACTURING COMPANY

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ABSTRACT

Aleksi Rosenius: Establishing Predictive Maintenance Business in a Furniture Manufacturing Company
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The objective of this study was to find out how to establish predictive maintenance business in a furniture manufacturing company. The target organization is starting the development work with maintenance business but needs external resources for that. Usually, there is no organized maintenance in furniture business, since the products are seen as consumables, which will be disposed or reused at the end of their life cycle. However, the target organization is producing products that include technological and technical solutions and wants to lengthen their lifetime.

This research was conducted as a case study, which intended to create a solution for one target organization's problem. Maturity model thinking was used as a starting point for this study. According to that, developing maturity will simultaneously develop the comprehensive capabilities of an organization, which will assist in the thorough problem solving. In this study, a literature research was conducted, which created the theoretical background for the whole thesis. The basic ideas and different strategies for organizing maintenance are introduced in the theoretical background. Also, the basics of maturity model thinking and different already created maturity models for maintenance development are addressed. Based on the theoretical background, a customized maturity model was created in cooperation with the target organization. That maturity model includes different subjects called dimensions, which include the essential matters regarding predictive maintenance development. These dimensions were evaluated with interviews that were conducted with the employees of the target organization. The interviewees were asked to evaluate the current maturity state of maintenance, in order to see where the organization is at the moment. The target maturity state for the future was set in a workshop that was also held for the employees of the target organization. Based on the information gained, a roadmap was created for the predictive maintenance business development.

As a result from this study, the current maturity state and two different target maturity states were received. Based on the current maturity state, the target organization is at the beginning of establishing a maintenance business. They do not have the needed capabilities to offer predictive maintenance services to their customers. The major development areas were seen to be in data and analytics usage, technology implementation and skills acquisition. Two target maturity states for the future, short-term and long-term, were set in collaboration with the target organization. The short-term targets were set on a moderately high level, which means that the organization must start developing their capabilities as soon as possible and across the different organizational units. In order to achieve the target states, a roadmap for the development process was created. This roadmap includes recommendations for each dimension in the maturity model. By following the roadmap, the target organization is able to increase their maturity and thus, their capabilities regarding predictive maintenance.

Keywords: maintenance, predictive maintenance, maintenance development, maturity model, maturity, roadmap

TIIVISTELMÄ

Aleksi Rosenius: Ennakoivan huoltoliiketoiminnan perustaminen huonekalualan yrityksessä
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Tämän diplomityön tavoitteena oli selvittää, kuinka huonekaluja valmistavalle teollisuusyritykselle voidaan luoda ennakoivaa huoltoliiketoimintaa. Kohteena oleva yritys on aloittamassa kehitystyön huoltoliiketoiminnan parissa, mutta tarvitsee siihen ulkopuolista apua. Huonekalualalla ei yleisesti ottaen ole yritysten toimesta järjestettyä huoltoliiketoimintaa, sillä tuotteet koetaan usein kulutustavaroiksi, jotka elinkaarensa päässä hävitetään tai uusiokäytetään. Kohdeyritys valmistaa kuitenkin tuotteita, jotka sisältävät erilaisia teknologisia ja teknisiä ratkaisuja, ja siksi haluaa pidentää niiden käyttöikää.

Tutkimus toteutettiin tapaustutkimuksena, jossa yhdelle kohdeorganisaatiolle pyrittiin luomaan ratkaisu heidän ongelmaansa. Lähtökohtana käytettiin kypsyysmalliajattelua, jonka mukaan kokonaisuuksien kypsyyttä kehittämällä kehitetään samalla yrityksen kokonaisvaltaisia kyvykkyyksiä, jotka auttavat ongelman perinpohjaisessa ratkaisemisessa. Tutkimuksessa toteutettiin kirjallisuuskatsaus, jonka perusteella luotiin teoriapohja koko tutkimukselle. Teoriaosuudessa käsitellään huollon perusperiaatteita ja erilaisia strategioita huoltoliiketoiminnan järjestämiseksi. Lisäksi käsitellään kypsyysmalliajattelun perusteita, ja tuodaan esille esimerkkejä huollon kehityksessä käytettävistä kypsyysmalleista. Näiden tietojen pohjalta luotiin yhteistyössä kohdeyrityksen kanssa heitä varten kustomoitu kypsyysmalli, joka sisältää ennakoivan huoltoliiketoiminnan perustamisen kannalta oleellisia asiakokonaisuuksia. Näitä kokonaisuuksia arvioitiin haastattelututkimuksella, jossa kohdeyrityksen työntekijöitä pyydettiin arvioimaan jokaisen osa-alueen tämänhetkistä kypsyyttä. Lisäksi järjestettiin työpaja, jossa tarkoituksena oli kohdeyrityksen työntekijöiden kanssa asettaa kypsyystavoitteita tulevaisuuteen. Näiden tietojen pohjalta luotiin suunnitelma, jota kohdeyritys voi käyttää kehittäessään huoltoliiketoimintaa.

Tämän työn tuloksena saatiin selville kohdeyrityksen tämänhetkinen tilanne huollon suhteen, sekä kaksi erilaista tavoitetilaa tulevaisuuteen. Tämänhetkisten tulosten perusteella yritys on vasta hyvin alussa huoltoliiketoiminnan luomisen kannalta. Heillä ei vielä ole tarvittavia kyvykkyyksiä tarjotakseen asiakkailleen huoltopalveluita, varsinkaan ennakoivia huoltopalveluita. Suurimmat kehityskohteet nähtiin olevan datan ja analytiikan käytössä, teknologioiden implementoinnissa sekä taitojen ja osaamisen hankinnassa. Tutkimuksessa yhteistyössä kohdeyrityksen kanssa asetettiin kaksi tavoitetilaa tulevaisuuteen; lyhyen aikavälin sekä pitkän aikavälin tavoitteet. Näiden tavoitteiden saavuttamiseksi tutkimuksessa luotiin suunnitelma, jonka avulla yritys voi pyrkiä kehittämään toimintojaan huollon suhteen. Suunnitelma sisältää suosituksia jokaiselle kypsyysmallissa esitetylle kokonaisuudelle, joita noudattamalla yritys pystyy kasvattamaan kypsyyttään ja sitä kautta kyvykkyyksiään huollon suhteen. Koska kohdeyritys ei ole aiemmin keskittynyt lainkaan huoltoliiketoiminnan rakentamiseen, tämän tutkimuksen avulla heillä on mahdollisuus aloittaa sen suunnittelun ja toteutuksen luominen.

Avainsanat: huolto, ennakoiva huolto, huollon kehitys, kypsyysmalli, kypsyys

PREFACE

What a journey it has been. I started studying at the Tampere University of Technology in 2015. That university is now five years later called Tampere University, and it has created the person I am today. It was a right choice for me to start studying at my hometown and it has already given me the opportunities that I would have never imagined receiving.

I would like to thank professor Hannu Kärkkäinen and associate professor Henri Pirkkalainen for creating guidelines and providing help for this whole process. I also want to thank the target organization for giving me the opportunity to develop this large entity and allowing me to continue the work in the future. I also want to thank all my colleagues who helped in the process by participating in the interviews and giving advice. A big thank you to Riikka Kovero and Veikko Lindberg for giving me the topic of this thesis and helping me at each turn during the last months.

Maria, thank you for supporting me during the good and the bad times. I wouldn't have managed to do this without you. I also want to thank my friends and family, especially my brother, who have all made a smile on my face and encouraged me over the years at the university.

Tampere, 14th of May 2020

Aleksi Rosenius

CONTENTS

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LIST OF ABBREVIATIONS

CBM	Condition-Based Maintenance
CM	Corrective Maintenance
CMM	Capability Maturity Model
ERP	Enterprise Resource Planning System
IIoT	Industrial Internet of Things
IoT	Internet of Things
IT	Information Technology
KBM	Knowledge-Based Maintenance
ML	Machine Learning
PdM	Predictive Maintenance
PM	Preventive Maintenance
RxM	Prescriptive Maintenance

1. INTRODUCTION

The subject of this master's thesis is *Establishing predictive maintenance business in a furniture manufacturing company*. This study focuses on creating and developing a new business for a company that operates in a field, where maintenance as a business is an unknown concept.

This chapter introduces the background for this thesis and the research questions that are used to solve the research problem. The structure of this whole study is also presented in this chapter.

1.1 Research background

After sales has become a big part of the business for different industrial and manufacturing companies during the last few decades. Maintenance, as a part of the after sales services, makes a significant amount of the whole revenue for many industrial actors nowadays. For example, big engineering companies can make almost the same amount of money out of selling their products than they are getting from after sales services. (Gebauer et al., 2006; Straehle et al., 2015)

There are different approaches in organizing maintenance with different strategies or types. Predictive maintenance is one of the types, which involves data and information in forecasting possible needs for maintenance. It is commonly used in different organizations in manufacturing industry and it has changed the way maintenance should be provided by these manufacturing companies. (Elphick & Jameson 2011; Mehta & Reddy, 2015)

Usually, maintenance is associated with big industrial companies, which are providing maintenance services for their complex machines and equipment (Mehta & Reddy, 2015). As all industries are now trying to find new ways of creating better customer experience and new revenue models, furniture industry has become interested in maintenance as well. Maintenance is not generally combined with furniture manufacturers, as their products are usually seen as consumables, but the target organization of this study wants to create a new kind of culture in the whole industry.

One commonly used method for business development is maturity model. These models are used in evaluating the current situation in a certain field of expertise and setting targets for the future (Wendler, 2012). Maturity models have not been used in developing maintenance processes very frequently, which means that there are not a lot to refer to. Luckily, maturity models have been commonly used in, for example, information technology (IT), data analytics and sales processes development, so they can be modified and combined to fit the needs of maintenance development as well. (de Bruin et al., 2005; Kohlegger et al., 2009)

This research aims to figure out how predictive maintenance business could be established to an organization that is manufacturing furniture by creating a maturity model for the development process. The target organization for this study is only at the beginning of maintenance business development and wants to know what they should do in order to provide predictive maintenance for their customers.

1.2 Research problem and questions

As already mentioned earlier, furniture market and businesses do not usually have any kind of maintenance business included. Furniture are seen as consumables, which will be disposed or recycled at the end of their life cycle. However, the target organization, which is introduced later on in this study, produces products that include technological devices and other technical solutions. Their products are moderately expensive, so to keep them working properly and making them more durable, the products need maintenance.

The target organization does not currently offer any kind of maintenance services to their customers. The objective of this study is to find out where the organization currently is with maintenance business and where they want to be in the future. For that cause, a maturity model is customized and used in evaluating the current and target maturity state of the organization.

Based on the research problem and objective, the main research question of this study is:

- **How to establish predictive maintenance business in a furniture manufacturing company with the help of maturity models?**

The main research question is very wide and includes a lot of different aspects to the whole subject. To be able to answer to that question, seven minor research questions have been created:

- **How maintenance is usually done in manufacturing companies?**
- **What is predictive maintenance?**
- **What are maturity models?**
- **How maturity models can help to define the level of maintenance in an organization?**
- **What is the current state of maintenance in the target organization?**
- **What is the target state of maintenance in the target organization?**
- **How the organization will achieve the target state?**

The customized maturity model is used in evaluating the current and target maturity state of the target organization, as stated above. After these operations have been done, recommendations for future development process are given with the help of a roadmap, which the target organization is then able to use in their own development work.

1.3 Research structure

This study consists of eight different chapters. Chapter 1 introduces the subject and creates background for the whole study. It also includes the research problem and questions, which will be answered in this study. Chapters 2 and 3 include the theoretical background of this study. In chapter 2, maintenance in manufacturing companies and different maintenance approaches are introduced. Chapter 3 creates the theoretical background for maturity models, which are used in this study to create frames for the development of maintenance business. There are also examples of maturity models used in maintenance development.

Chapter 4 introduces the research methods and the target organization of this study. It introduces the research methodology, including research philosophy, approach and strategy that are used in this study. It also gives background for the interviews and workshops, which are then later conducted and used for the target organization's evaluation. Chapter 5 introduces the customized maturity model for the target organization. It thoroughly presents the way of customizing the model for a specific company and gives justification for different decisions concerning the maturity model.

Chapter 6 consist of results from the interviews and workshop held to the employees of the target organization. The current and target maturity state of the company was evaluated with the help of the customized maturity model, and the results of those are visualized and presented there.

Chapter 7 includes the conclusions of the interviews and workshop, and also introduces a roadmap for achieving the target maturity state. Chapter 8 is the last chapter of this study, and it includes the answers to the research questions. Evaluation of this study and suggestions for future research topics can also be found from this chapter.

2. MAINTENANCE IN MANUFACTURING COMPANIES

After sales has become a crucial part of whole business and revenue for today's manufacturing companies. After sales can be described as services, which happen after a company has already sold a product to a customer. So, the company that has sold products to its customers, is providing services and support regarding those products to the customers. (Chen, 2018; MSG, 2019) The key thing here is to make and keep the customers as satisfied as the company can, because of possible future sales and new customers.

Theodore Levitt noted the need and importance of after sales already four decades ago in his article (1983), where he introduced the change of sales processes and approaches. According to him, a customer is much more willing to come back to the seller, if the business happening after the initial sales is satisfying the customer. Timothy L. Wilson continued that in his article (1999) stating that after sales has a strategic impact on the company providing these services. It creates customer satisfaction, but on the other hand, gives the company a possibility to make business and get new customers.

Nowadays, after sales is commonly provided as a sold service, which gives revenue to the company that has sold the product initially. The services can be, for example, spare-part business, maintenance services or user training. (Chen, 2018; Keap, 2019) Borchardt et al. stated in their article (2017) that after sales services can be even more stable source of revenue than selling products in the manufacturing industry. That is one of the reasons why it should be a crucial part of every manufacturing company's business.

After sales services can be a big part of the manufacturing company's whole revenue. In 2006, Gebauer et al. conducted a study, where they researched the amount of revenue manufacturing companies receive from after sales services. The results of that study are presented in figure 1.

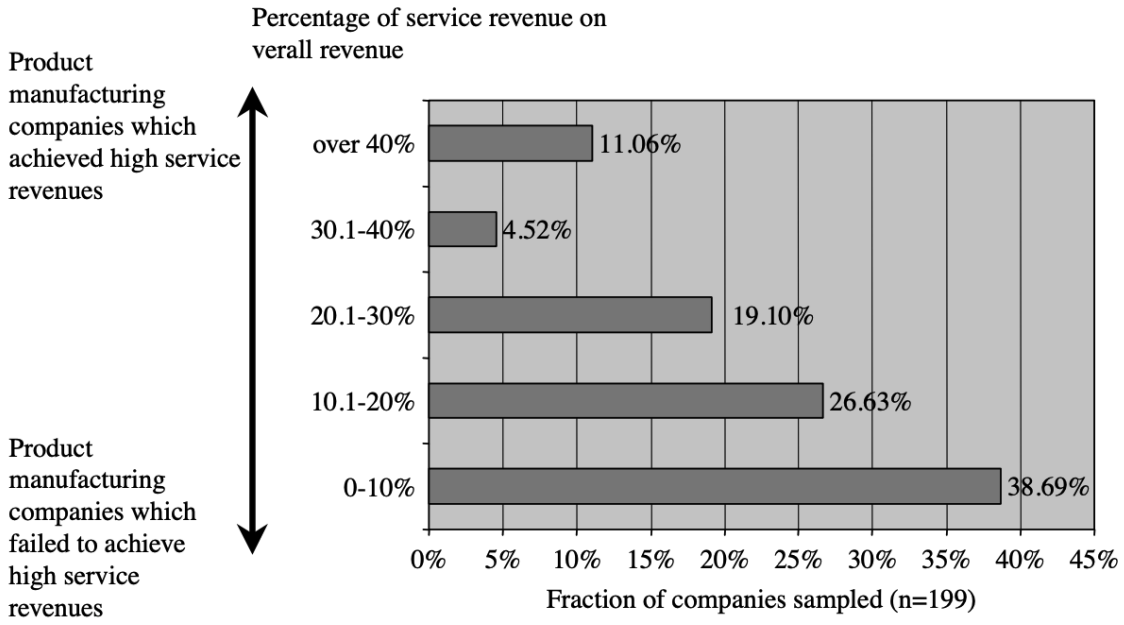

Figure 1. *Service revenue in manufacturing companies (Gebauer et al., 2006)*

As we can see from the figure 1, over 10% of the manufacturing companies received over 40% of their revenue from after sales services. On the other hand, almost 40% of the manufacturing companies could not make their after sales services to reach even 10% of the revenue. (Gebauer et al., 2006) This means that there are a lot of manufacturing companies who have not either understood the possibility or succeeded in selling these services. Regarding to that, there are a lot of hidden potential in these services, and in a right way of doing things, they can create business.

That study was conducted multiple years ago, and the situation has changed significantly since then. In Straehle's et al. article (2015), they state that service business brought 22% of total revenue as an average among hundreds of industrial companies. Comparing that to the results in figure 1, it can be said that service business has grown in 10 years a lot. If that continues in the future, after sales services will become even bigger part of manufacturing companies' business (Devine, 2018).

As stated above, maintenance is one of the possible options of after sales services to create revenue for industrial companies. In this study, the focus will be only on these maintenance services. In the next subchapters, maintenance business of manufacturing companies is introduced, as well as a data-driven approach for maintenance business.

2.1 Maintenance in general

Maintenance is one of the services a company can provide to its customers after selling the products to them. The basic idea of it is to keep and ensure that all necessary products and equipment are working as they should all the time without any failures. (Krar, 2015). It should be done regularly and systematically, and in a way all the parties involved are benefitting from the operations somehow. Doing that needs strict planning and functional structuring, which can be achieved with different methods.

Generally, maintenance is considered to be a part of industrial companies' everyday business. Big machines and technical products need maintenance to be able to work properly. Usually maintenance links to engineering and technical work, which are necessary in understanding how the machines are working. (Mehta & Reddy, 2015) Maintenance can also be seen in the consumer side, because of, for example, mobile devices and cars, which all need maintenance regularly.

Maintenance, in general, has a lot of positive aspects, why it should be done. Properly working equipment and products are essential to most of the companies, for example, in keeping the company's effectiveness and production quality at high level at all times. (Mehta & Reddy, 2015). It may be considered as a healthcare of devices and products, which means that it must be done regularly. With right maintenance, companies are able to save a lot of money compared to a situation where machines do not work, and production must be shut down. (Krar, 2015)

Maintenance services create also other kind of value for the customer and the company providing maintenance. Besides economical value, maintenance can, for example, start a long-lasting cooperation between the two factors, where the customer can help in research and development of new products. It can also create a lot of customer satisfaction and in that way boost the reputation of the maintenance-providing company among the industry. (Ali-Marttila, 2015) The objective of maintenance operations should be multidimensional and profitable for all parties, and the company providing these should aim for other values also.

Various industrial and other manufacturing companies have started to offer maintenance as a service to their customers. As already stated in the previous chapter, after sales services create a big amount of revenue for these companies, and maintenance business is a part of that revenue stream. (Chen, 2018). To be able to provide maintenance for customers and make business out of it, it should be somehow planned and logical.

That's why there are different types and approaches of maintenance developed for that cause.

2.2 Maintenance types and strategies

Maintenance can be divided into different kind of types in various ways, depending on a source. One of the most common division types for maintenance is to divide it into proactive and reactive types of maintenance. Proactive maintenance means that maintenance is done before a product is broken, and reactive maintenance means that the maintenance is done after a product is already broken or has some kind of malfunction. These two different maintenance types include different kind of maintenance strategies depending on their characteristics. (Elphick & Jameson, 2011; Hupjé, 2018; Ranade, 2019) In the figure 2, the most common maintenance types and strategies are introduced.

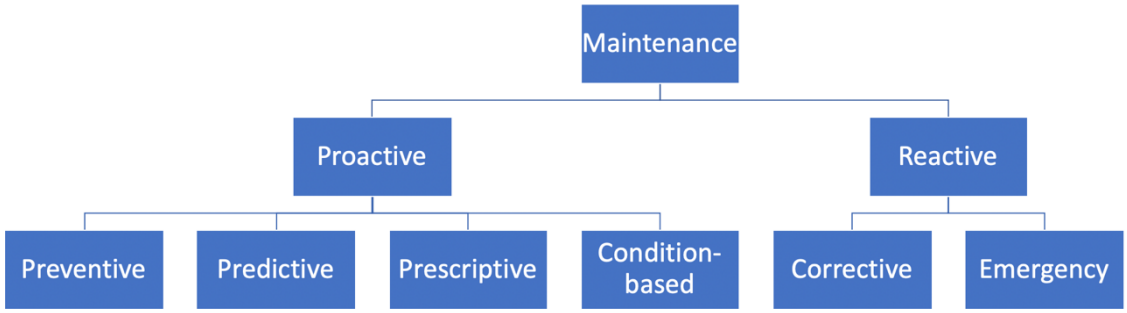

Figure 2. *Types of maintenance (adapted from Elphick & Jameson, 2011; Hupjé, 2018; Ranade, 2019)*

Proactive maintenance includes maintenance strategies such as preventive, predictive, prescriptive and condition-based maintenance. Reactive maintenance includes maintenance strategies, such as corrective and emergency maintenance. There are a lot of other strategies as well, but these are the most common ones. (Elphick & Jameson, 2011; Hupjé, 2018; Ranade, 2019). These maintenance strategies are briefly presented in the table 1.

Table 1. *Maintenance strategies*

	Maintenance strategy	Description	Advantages	Disadvantages
Proactive	**Preventive**	Regularly performed maintenance to minimize the possibility of failures.	- Keeps products operational all the time - Long-term costs cheaper	- A lot of planning required - Can be expensive to establish
Proactive	**Predictive**	Predicting possible future failures so that it can be fixed or replaced just before it fails.	- High reliability of products - Possibility for a failure is low	- High costs to establish and maintain - Requires planning and know-how
Proactive	**Prescriptive**	Collecting and analyzing data from products to show when a failure is going to happen and why.	- Shows also the reason behind failures - Possibility for a failure is minimal	- Can be really expensive - Needs high-quality plans and expertise
Proactive	**Condition-based**	Monitoring the actual condition of a product at all times and indicating when something is about to fail.	- Gives constant feedback of conditions - Keeps operations working at all times	- Need of technological solutions for products - Can be really expensive
Reactive	**Corrective**	Repairing and fixing already broken products and restoring broken systems.	- Moderately cheap - Simple processes	- Unpredictability - Safety risks for organization
Reactive	**Emergency**	Repairing and fixing broken products that can cause threats to profitability and lives to an organization.	- Doesn't require much planning - Moderately cheap	- Can cause major costs and other threats - Unpredictability

As we can see from the table 1, there are a lot of similarities between different maintenance strategies. All these strategies still exist for a reason, and the differences and more detailed characteristics of them are explained next.

2.2.1 Reactive maintenance

Reactive maintenance has been the common maintenance type for long. It means actions, which are done after the product or piece of equipment has already broken. It is a very costly way of doing maintenance and it is very difficult to strategically manage. Because reactive maintenance means run-to-failure type of maintenance, it cannot be prevented or forecasted in any way. (Mehta & Reddy, 2015, p. 525) On the other hand, reactive maintenance does not require as much labor costs as proactive maintenance, and is less time consuming, because the work is done after the product breakdown. From the maintenance provider's point of view, it could be a good option for organizing the maintenance business. (Segzdaite, 2018) However, when taking into account the customer, reactive maintenance is nowadays considered as a poor way of providing service, although it has historically been the description for maintenance for a long time.

Reactive maintenance is usually divided into different strategies, which are guidelines for how to arrange the maintenance business. Two of those strategies are corrective maintenance and emergency maintenance.

Corrective maintenance

Corrective maintenance (CM), or breakdown maintenance, strategy means an approach, where a product or piece of equipment is repaired after the failure has occurred (Galar & Kumar, 2007). Usually, there are no maintenance plans or strict rules attached to this strategy, because of its uncertain nature. It is commonly used in companies, where the operations do not require expensive spare parts or highly technical know-how of a certain product's functionality. However, it is still a very common strategy also for other kind of manufacturing companies, which would require a more systematic way of maintenance for their operations. (Chan & Young, 2019a).

Corrective maintenance is usually considered as a very cheap strategy to organize maintenance processes. It can be done with a quite small amount of resources, such as tools or maintenance organization. (Deighton, 2016). It is also a very simple solution and does not require much planning or strict processes around it.

Corrective maintenance is highly unstable strategy to use because of multiple reasons. The failures cannot be predicted beforehand in any way, because maintenance needs are not inspected regularly, and the condition of a machine is unknown. It can cause a stoppage in a manufacturing process or, in a worst-case scenario, in the whole production of a company. (Galar & Kumar, 2017). The repair times are also unpredictable, because the reasons behind the failure are most likely unknown, and usually the root causes will not be examined thoroughly (Deighton, 2016).

Emergency maintenance

Emergency maintenance is very much similar to corrective maintenance in a way of handling the maintenance needs. They both are categorized as reactive maintenance strategies, which means that the maintenance is done after a breakdown or a failure. (Chan & Young, 2019a) The main difference between corrective and emergency maintenance lies in their nature.

Emergency maintenance is done whenever a failure happens in a product or a system and is critically causing threats to the organization's actions. These threats can be, for example, stoppage in production causing major impacts on the profitability of the company or life-threatening threats to employees or to the premises of a company. (Zhao & Yang, 2018; Chan & Young, 2019b)

As corrective maintenance, it is moderately cheap to organize because it does not require much planning beforehand. A maintenance company is required and alarmed whenever a breakdown happens, which means that the process is very simple. On the other hand, using emergency maintenance strategy can have a major negative impact

on company's operations. A stoppage in production can cause severe issues in cashflow and it can endanger the whole business for a long time. (Chan & Young, 2019b)

Emergency maintenance is a good example of a strategy, which should be implemented with another maintenance strategy. Emergencies can happen although a company has planned everything and uses, for example, proactive maintenance strategies, so it can be useful to have plans for emergency situations as well. (Westerkamp, 2013, pp. 97-99)

2.2.2 Proactive maintenance

Proactive maintenance has become the most common type of maintenance nowadays. It is an approach, where maintenance is done before any problems occur. Proactive maintenance means also finding the root cause of the problem and fixing that, before anything crucial would happen to the business. (Exner et al., 2017) Proactive maintenance is usually somehow planned or scheduled beforehand and the usage of information and data is very common (Bigdeli & Safi, 2005). Companies want their products to work properly at all times, which has led to a situation, where they are willing to pay service providers beforehand to keep them in a good shape.

The differences between reactive and proactive maintenance types are significant, and nowadays it is highly recommended to use proactive strategies to organize the maintenance needs (Hupjé, 2018). As Steve Krar states in his article (2015), maintenance should be approached with more preventive and predictive way, not in a way where something has failed and is then fixed.

As reactive maintenance, proactive maintenance as well can be implemented in various strategies. The most common ones are preventive, predictive, prescriptive and condition-based maintenance. These strategies are presented more thoroughly next.

Preventive maintenance

Preventive maintenance (PM) strategy is one of the strategies for reactive maintenance. It means that maintenance services and checks are done on a regular basis to prevent any kind of failures in products or pieces of equipment. Preventative maintenance is usually planned and has regular time periods, in which the maintenance should be done. (Mehta & Reddy, 2015, p. 525) The main idea behind this preventive strategy is to reduce the number of breakdowns and other failures in products with a systematic way of doing maintenance (Galar & Kumar, 2017).

The positive aspects of using preventive maintenance is, for example, that it keeps the products operational at all times because of the regular checks. It also saves money in long-term, because the corrective repairs have to be done less frequently and they are less expensive. Preventive maintenance strategy also increases safety in an industrial environment, when the products and machines are surely working correctly all the time. (Chan & Young, 2019a).

On the other hand, preventive maintenance can be quite expensive to establish. It requires a lot of planning and duties, such as creating organization for maintenance, in advance. It is also quite demanding strategy, because it requires that the created schedules are implemented as they should and that the tasks are done correctly. (Galar & Kumar, 2017; Chan & Young, 2019a). Preventive maintenance strategy is still a very good option for different companies to take into use, because it will make the reactions to failures a lot faster than a reactive maintenance strategy.

Predictive maintenance

Predictive maintenance (PdM) strategy is a little bit more advanced strategy than preventive maintenance strategy. It is used to predict possible breakdowns and failures, which could happen in the near future. (Fedele, 2011, p. 44) It also helps to identify where those failures are probably coming from, and that way gives a chance to fix the root causes of them. Predictive maintenance is based on measurements of current conditions of a product and relies heavily on the information and data gained from them. (Mehta & Reddy, 2015, p. 525)

As the information is usually real-time condition information, predictive maintenance is a good option for monitoring and reacting to upcoming breakdowns. The possibility for a failure is quite low, as the information comes straight from the products. (Nguyen, 2018) It also creates a reliable environment around different machines and products, because the failures can be predicted before anything major happens. Predictive maintenance can also make the scheduling of different maintenance visits a lot easier, and that way reduce the needed amount of resources. (Fedele, 2011, p. 45; Mehta & Reddy, 2015, p. 525)

Predictive maintenance usually needs a lot of planning to be able to succeed. Companies should have already thought about maintenance or have some kind of strategy in use before implementing predictive strategy. It is quite expensive to establish, because the information needs to be collected with technological solutions and analyzed either manually or automatically. (Soni, 2019) The initial investment can be big, which means that

every organization is not able to implement this strategy to their maintenance plans (Chan & Young, 2019a).

Prescriptive maintenance

Prescriptive maintenance (RxM) strategy is very similar to predictive maintenance strategy but is a little bit more advanced in usage of data and information. Prescriptive maintenance strategy is also used to predict and prevent future failures and breakdowns, and to identify the root causes of these failures. But, in addition, it also gives suggestions how to repair the breakdowns, and it recommends solutions for changes to prolong the lifecycle of different products. (Beck, 2019; Ranade, 2019) Prescriptive maintenance is one of the applications of Industrial Internet of Things (IIoT), which will be discussed more later in this study. It requires a lot of complicated technologies to work properly and be useful, but there is a major potential hidden inside this application. (Vavra, 2017)

Prescriptive maintenance has multiple advantages in using it. For example, the matter that this strategy shows also the reason behind failures and breakdowns, and also gives suggestions how to deal with them and how to improve the surroundings in a way these failures will not happen again, makes it very useful strategy for maintenance. (Ranade, 2019) It obviously makes the maintenance a lot easier and keeps production at companies working all the time. Using this strategy will also decrease the required time for repairs, because the information about recommended maintenance operations are coming straight from the products (Penny, 2019).

As predictive maintenance, prescriptive maintenance strategy is very expensive to implement. The required technological and technical devices can be expensive, as well as the systems needed to analyze the collected information. (Soni, 2019) It also needs a lot of expertise to assemble the devices and to make a working maintenance plan for prescriptive strategy (Nguyen, 2018). The processes and procedures must be thought thoroughly to be able to make the most out of this highly developed maintenance strategy.

Condition-based maintenance

Condition-based maintenance (CBM) strategy is commonly defined as a way of making maintenance decisions based on information and data collected from a product and its condition (Jardine et al. 2006). Galar and Kumar introduce three steps of condition-based maintenance in their article (2017), which are data acquisition, data processing and maintenance decision-making. All these steps must be done in order, to make the most out of the maintenance strategy. As these steps indicate, this strategy relies heavily on data and information gained from the products and their conditions. It seeks for physical evidences about a failure that has happened or is happening in the near future. (Galar &

Kumar, 2017; Hupjé, 2018) The strategy itself is based on maintenance work, which is happening at the exact moment when the monitored condition parameters are decreasing to a certain point (Chan & Young, 2019a).

Using CBM strategy will give constant feedback about the conditions of different products and parts of equipment. From the information gained, it is possible and quite easy to organize the maintenance visits and needed repairs, whenever problems occur. With that data and information collected, the production sites are able to continue working at all times and without any interruptions. (Ranade, 2019) As all the other proactive maintenance strategies, CBM also shortens the time needed for repairs and improves safety in the production environment (Koons-Stapf, 2015). It can also reduce the costs of whole maintenance operations, when they are done at the right time and with right corrective actions.

As stated above, the collection of data is crucial in order to make CBM work. That obviously needs a lot of investments in the technological devices and systems. Firstly, those solutions must be found, but also the investment to those can be quite big. The processes for data acquisition and usage must also be developed in order to make this strategy work, which means that it will require a lot of high-level planning and development. (Hupjé, 2018; Chan & Young, 2019a) Nevertheless, condition-based maintenance strategy can be, when properly implemented, a very good option for organizing maintenance in a company. It is quite similar to prescriptive maintenance, but it is not as advanced.

2.3 Data-driven maintenance

As the technology has developed so much and fast in the past years, industrial companies have taken the maintenance and service to another level as well. With the help of Industrial Internet of Things (IIoT) and other technological solutions, maintenance can be done based on a real-time data collected straight from the products. (Ranade, 2019). This data-driven maintenance is nowadays very common, and many of the previously mentioned proactive maintenance strategies are based on data-driven approaches. Predictive, prescriptive and condition-based maintenance strategies all use data and information gained either from the products or their surroundings to indicate the need of maintenance or repairs.

The concept of Internet of Things (IoT) means, at simplest, connecting normal everyday items to the internet or to each other (Morgan, 2014). When the concept is taken into industrial environment, the result is Industrial Internet of Things (IIoT). This means connecting all kinds of machines, devices and products to the internet. With this concept,

manufacturing companies are able to, for example, get information about their operations, communicate with their production machines and automatize different actions in their operation. (Gilchrist, 2016)

From the IIoT, a concept called Industry 4.0, which refers to the fourth industrial revolution, has arisen. It means adoption of computers and automation into production, and using data and machine learning to make the production more effective, more productive and smarter. (Marr, 2018) As the Industry 4.0 enables the usage of data and information in machine work and controlling different productional operations, maintenance work can be attached to that as well. The potential of using data and information in maintenance was noticed shortly after different companies started using machines and products that were connected to the internet. The data-driven maintenance concept was born from there, and today it is used in different companies and industries. (Ranade, 2019)

As stated above, the different proactive maintenance strategies require the usage of IIoT to be able to get information and data from the products that need maintenance. The usage of data has come to stay, and to be competitive, companies must take this into account and shape their current procedures to match the needs of the markets. Although those different strategies exist and are used in few companies, the full potential has not been reached yet, but will be in the future.

3. MATURITY MODELS

The third chapter in this study introduces the basic theory behind maturity models and their characteristics. The general structure and content of maturity models are introduced, as well as the methods for developing them. This chapter also includes introduction of few maturity models developed for maintenance development processes.

3.1 Basics of maturity models

The ground for maturity thinking was based already in the 1930's. The first model that used maturity as a tool dates back to the 1970's, when quality management process maturity grid was proposed for the first time. Since then, maturity models have been used in different development projects in different fields around the globe. One of the most well-known maturity models, Capability Maturity Model (CMM), was created two decades after the initial invention of maturity models for software development processes. Because of these reasons, the roots of the whole maturity model concept can be presumed coming from information technology and software industry as well as from quality development. (Wendler, 2012)

To understand the basics of maturity models, a definition for maturity itself is needed. In the article by R. Wendler (2012), he claims that Oxford English Dictionary describes maturity as "the state of being complete, perfect or ready". He also states, that maturity is commonly used for measuring different capabilities of a certain organization or other party. Therefore, the purpose of models using maturity is to indicate when different objects that are examined in each case reach the best possible state. This means that the maturity has an end point, where it can no longer develop further. (Wendler, 2012)

To be able to develop in a certain area, the organization or other party using maturity models must develop their capabilities. The capabilities are often described as certain aspects of reality or as the ability to do something. Thus, in order to use maturity models to develop a certain area, the users must find the right capabilities that makes the user develop further and focus on these. (Kohlegger et al., 2009; Wendler, 2012)

The maturity models are usually divided into different levels called maturity levels, which represent the maturity of the subject in question. In order to develop the capabilities, the user of the maturity model must develop within the maturity levels. The amount of maturity levels usually varies between four to seven, where the most common approach is

to use five maturity levels. The levels are cumulative stages, where the higher level always builds on the lower level. The requirements of lower maturity levels must be filled to be able to proceed to the next level. Whenever a user of maturity model is developing from lower maturity level to the next maturity level, the capability is increasing. (de Bruin et al., 2005; Kohlegger et al., 2009) This is the basic idea of maturity models, where the objective is to find out where the target of the research currently lies, and where it desires to be in the future. This can be defined as what is the current maturity level, and what is the desired maturity level. With the help of the maturity models, it is possible to create plan of actions that eventually lead to the development of maturity and from that, the development of capabilities. The maturity levels should always have a description, to where the subject at the time is linked to. These descriptions should define the requirements at each level to be able to achieve them. (de Bruin et al., 2005; Kohlegger et al., 2009) An example of this maturity level thinking is presented in the figure 3.

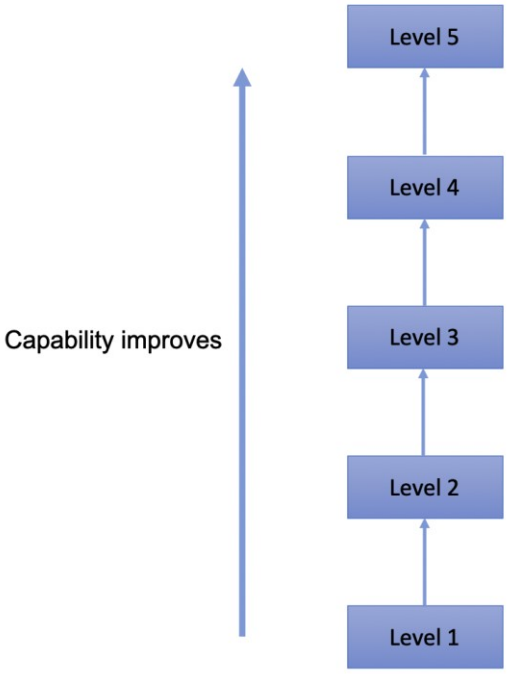

Figure 3. *Five levels of maturity (adapted from Fowler, 2014)*

There are different ways of structuring the maturity model concretely. Fraser et al. introduce in their article (2002) three groups of maturity models; maturity grids, hybrids and Likert-like questionnaires, and CMM-like models. Maturity grids are usually quite complex entireties, where each activity at each maturity level has text descriptions. Likert-like questionnaires are, in turn, quite simple maturity models. They consist of statements of practices, which organizations then use to score their own performance on a scale

from 1 to n, in which the n presents a number. Hybrids combine these different approaches, and usually they consist of overall maturity level descriptions, but does not include specific descriptions for activities. CMM-like models are more complex and formal kind of maturity models. There, a number of goals and key practices are specified to reach a desired level of maturity. (Fraser et al., 2002) A research made by Frick et al. (2013) states that the most common type of maturity models used in literature and researches is the maturity grid, although hybrid models are very hard to identify into any specific group.

Usually, maturity models consist of different dimensions, maturity levels and attributes. Dimensions are higher level entireties, which include a specific topic. The maturity levels are the steps, where the development is also developing the capabilities. Attributes are the descriptions and different matters concerning a specific dimension and maturity level. (Fraser et al., 2002) A general example of typical maturity model is presented in the figure 4.

	Dimension 1	**Dimension 2**	**Dimension 3**	**------**	**Dimension x**
Maturity level 1	Attribute 1.1	Attribute 2.1	Attribute 3.1	------	Attribute x.1
Maturity level 2	Attribute 1.2	Attribute 2.2	Attribute 3.2	------	Attribute x.2
Maturity level 3	Attribute 1.3	Attribute 2.3	Attribute 3.3	------	Attribute x.3
------	------	------	------	------	------
Maturity level y	Attribute 1.y	Attribute 2.y	Attribute 3.y	------	Attribute x.y

Figure 4. *Typical maturity model structure*

As we can see from the figure 4, the number of dimensions and maturity levels may vary depending on the situation the maturity model is used for. In order to develop the capabilities, the user of the maturity model has to develop their operations to match the attributes in the model. Whenever an organization or other party, which is using maturity model, wants to develop their capabilities, they must fulfill the requirements set on a specific maturity level and on specific attribute. (de Bruin et al., 2005; Kohlegger et al., 2009)

According to different resources (Kohlegger et al., 2009; Wendler, 2012) there is a large number of maturity models developed for different causes around the globe. They are used, for example, for business process development, product development, engineering or analytics development. To be able to fit the needs for the situation at hand, maturity

models should be customized or modified. Although there is a large amount of maturity models available, they usually do not directly match the needs of a certain organization. There are a lot of moving parts in businesses and the situations are always different, which means that the models must be adjusted. (Kohlegger et al., 2009; Frick et al., 2013; Van Looy et al., 2013) Luckily, there are different methods for creating and enhancing already developed maturity models.

3.2 Creating a maturity model

There are multiple different ways of creating a maturity model. Frick et al. mention in their article (2013) that the process of creating maturity models is not usually described in different publications, and therefore it is very hard to repeat those researches. However, there are few frameworks and methods created to develop maturity models. According to Frick's et al. article (2013), for example, generic framework for maturity model creation has been developed, as well as a procedure model for maturity model development. There are also other methods for developing maturity models, but these two were the most referenced and common methods that were found whilst conducting the literature research. (Frick et al., 2013) Both of these models are widely used as a base for different kind of maturity model development, and that's why they are excellent examples of procedures for that development work. These two methods are presented next.

3.2.1 Generic maturity model development framework

The generic framework model was introduced in the article by de Bruin et al. (2005). This framework is one of the most common development frameworks for maturity models, and it consists of six different phases. This framework is presented in the figure 5 and is then explained.

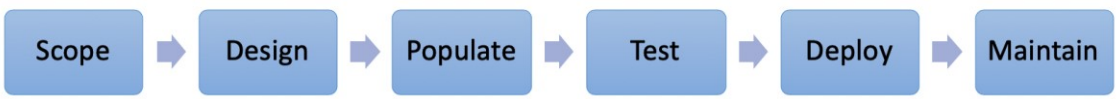

Figure 5. *Phases of maturity model development (de Bruin et al., 2005)*

The first phase of this maturity model development framework is defining the scope of the model. Deciding the scope of the maturity model will guide the other phases and will set boundaries for model usage, which makes this phase very important. This phase will set the focus of the model, which means the category the model will be targeted to. The focus can be very specifically tied into some category or it can be more general, which means that the model can apply to multiple different subjects. This decision about the

model's focus will also separate the model in question from other, already existing models. In this first phase, the stakeholders, which will be assisting in the model's development, are also decided. (de Bruin et al., 2005)

The second phase of this maturity model development framework is determining the design of the model. In this phase, the targeted audience of the model is decided, which can be, for example, internal or external. This phase also includes considering of the needs of the selected audience, for example, why they want to use the maturity model or what are they trying to achieve with the usage of the model. In this second phase, the stages of maturity should also be considered. The scale, number and characteristics of the stages should be decided using some of the approaches that were already presented previously. All in all, this phase focuses on the shape and overall design of the maturity model, which are necessary things to consider when developing one. (de Bruin et al., 2005)

In the third phase of this framework, the contents of the maturity models are decided. After the shape and design of the model has been developed, it must be determined, what are the matters this maturity model is used to measure and how this can be done. Identifying the key elements in an environment that is going to be evaluated with the maturity model is the most important thing in this phase. As shown previously in the basic structure of a maturity model, this phase is used to fill the blank spaces inside the model. Different attributes and dimensions should be thought here to be able to continue into the next phase. The key point is that the attributes and other components of the maturity model have to match the needs of the research case. This can be achieved by, for example, conducting interviews or using other research methods. (de Bruin et al., 2005)

Once the maturity model has been designed and populated, it must be tested to indicate possible mistakes in preciseness and relevance of it. That is the fourth phase of this development framework, where both the structure and the content of the model must be tested. The key points to test are validity, reliability and generalizability of the maturity model, in order to see if the model is really measuring what it was intended to measure and that the results gotten from the usage of the model are accurate and repeatable. (de Bruin et al., 2005)

The fifth phase of this maturity model development framework is deploying the model. The model must be made available for use to get a sight of it in real usage and to standardize it. There are two steps in deploying the maturity model, where in the first, the model must be published to a certain group of stakeholders that were initially a part of the development of the model. The second step is to take other stakeholders along and

to apply the model to previously uninvolved organizations or user groups. This will eventually lead to a situation, where the developed maturity model can be published out for global and possibly public usage. (de Bruin et al., 2005)

The sixth phase, which is also the last phase of this framework, is maintaining the maturity model's growth and use. Generally, maturity models are developing and evolving after the initial deployment, which means that it must be controlled somehow. As the knowledge and understanding increases across the different users, the changes needed to develop the model must be documented and managed by the developer of the model. (de Bruin et al., 2005)

3.2.2 Procedure model for maturity model development

The second method of developing maturity models is introduced in the article by Becker et al. (2009). Their model is called the procedure model for developing maturity models, and it consist of eight different phases. The phases of this model are presented in the figure 6.

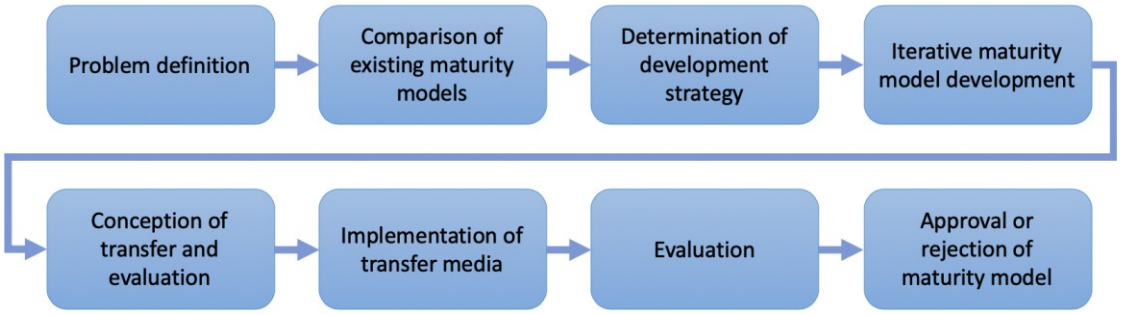

Figure 6. *Procedure model for maturity model development (adapted from Becker et al., 2009)*

The version in the figure 6 is a simplified version of the whole development model, and only the main phases of the framework are presented. The model itself is a lot more complex entity, where all the phases consist of different subphases and there are other moving parts around them.

The first phase in this procedure model for maturity model development is defining the problem for what cause the maturity model is going to be developed for. The targeted domain and the target group must be decided, as well as the reason behind the development of the maturity model. There must be a demand for the development, and it must be relevant to some subject in order to make the whole development process reasonable. The second phase after defining the problem is a comparison of existing maturity models. In order to start the development process, it must be researched that there are

no similar existing maturity models, which could be used rather than develop a completely new model. (Becker et al., 2009)

The third phase in the procedure model is determination of the design and development strategy. When developing maturity models, it is possible to create a completely new model, enhance already existing maturity model or combine different models to fit the needs of the situation at hand. In any case, the approach for the development and the strategy for that must be determined before the next phase. In the fourth phase, which is one of the most important phases, the maturity model is actually developed in iterative manners. This fourth phase has multiple different subphases, which include selecting the design level, selecting the approach, designing the model section and testing the results. All these subphases should be iterated and done multiple times to get the best possible result. This is the central part of developing maturity models, where the model itself gets the shape and contents. (Becker et al., 2009)

After the design of the maturity model has been decided and executed, forms of transferring results and concept of evaluation must be determined. This fifth phase takes into account how the results from the usage of maturity model are transferred for academic and other user groups' use. The evaluation of the results must also be determined in this phase. The sixth phase of the procedure model is implementing the transfer media, which means that the maturity model must be made accessible for all the defined user groups. The transferred media must be targeted to those groups and the results must be accessible by them. (Becker et al., 2009)

The seventh phase of the procedure model for maturity model development is evaluation. The maturity model should be evaluated to see if it provides the benefits that were expected and that it created a solution for the problem it was initially constructed for. This evaluation can be done in small user groups, which will test the maturity model for a real-life case, or it can be published for broader audiences to get feedback about the usage of the model. The last phase of the procedure model is rejecting or approving the maturity model. If the model does not fulfill the requirements or give the desired value to the users, it must be taken out of the markets. In this phase, the result can also be re-designing the model starting from the problem definition. If the maturity model passes the evaluation phase and it is proven to be beneficial, it can be published for global use. (Becker et al., 2009)

3.2.3 Comparison of the development methods

These two presented models for maturity model development have a lot in common, but have also some phases and content, which are different from another. As the generic framework was developed at first for business development and the procedure model was developed for IT management use, the structure of these models could be much more divided, and they could differ a lot more. They are still very similar in their first phases, where the initial planning of the maturity model development is done. Both of the models address the scope and the problem, for which the maturity model is later being used. The design phase is also quite similar in both of these models, although the procedure model is more iterative in this step. (de Bruin et al., 2005; Becker et al., 2009)

The importance of testing and evaluation of the maturity model is well emphasized in both of the approaches. Although the methods are initially made for different kinds of needs, they have surprisingly much in common. In the big picture, the procedure development model has more phases, and it emphasizes the need for iteration in multiple parts of the development process. The generic framework is applicable to various different fields and situations, which makes it a little bit more versatile. The generic model is also focusing more on the overall usage of maturity models, whereas the procedure model follows more strict design guidelines. (Frick et al., 2013)

All in all, both of these maintenance development methods are useful, especially when there are not many guidelines for maturity model development existing. These development models can be used widely between different fields and situations to create maturity models for different needs.

3.3 Maturity models related to predictive maintenance

There are few maturity models developed for improving maintenance and its processes, but a lot less when compared to other fields. As stated already above, analytics, IT and business development are probably the fields, which have most of the maturity models developed for. However, when maintenance is nowadays strongly connected to data and information usage, maturity models from those fields can be used as a reference for creating maintenance maturity models.

From the literature review made for this study, two maturity models that are close to predictive maintenance process development were found. These models are a reference model for prescriptive maintenance and a maturity model for data-driven manufacturing. (Weber et al., 2017; Nemeth et al., 2018) These two maturity models are presented next.

3.3.1 Reference model for prescriptive maintenance

Nemeth et al. present a reference model for prescriptive maintenance in their article (2018). The maturity model is based on a knowledge-based maintenance (KBM) model, which is used to develop a concept for optimizing maintenance processes (Nemeth et al., 2018). The model consists of different strategies for maintenance, of which few were already introduced in the previous chapter. The knowledge-based maintenance model is presented in the figure 7.

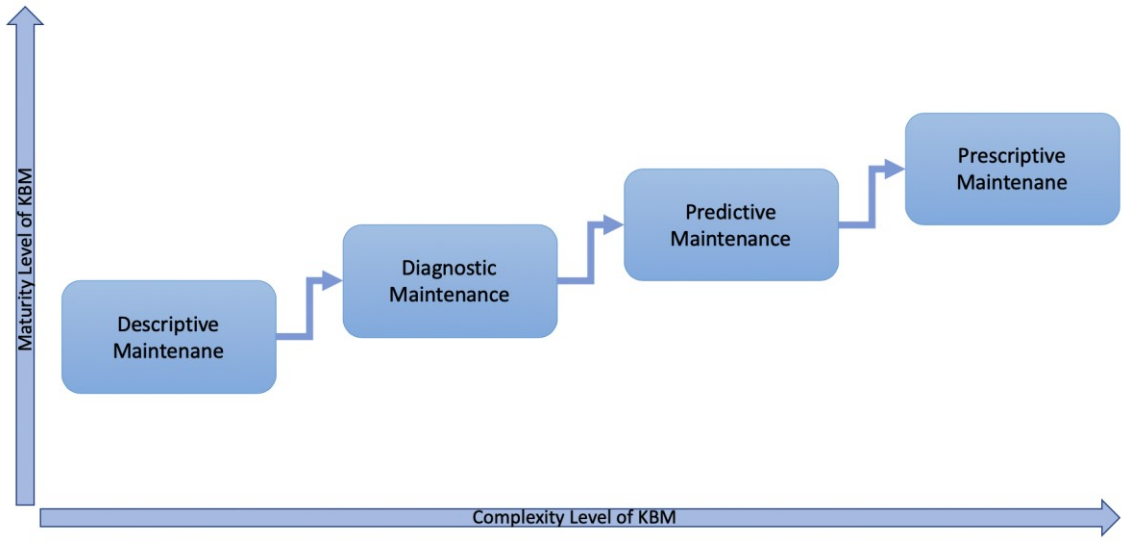

Figure 7. *Knowledge-based maintenance strategies (adapted from Nemeth et al., 2018)*

Descriptive maintenance is a strategy, where information about previous maintenance operations is used to find out the methods for future maintenance operations. Diagnostic maintenance means analyzing cause and effect relations from former maintenance operations and using them in upcoming maintenance operations. Predictive and prescriptive maintenance strategies were already explained in the previous chapter, but in short, they use real-time data to prevent maintenance needs. Prescriptive maintenance is the most developed strategy of maintenance, since it also offers recommendations about maintenance operations. (Nemeth et al., 2018)

The real maturity model, which is based on this KBM model, is a multidimensional matrix model, which pursues to increase the maturity of maintenance and data analytics. That maturity model is used to implement prescriptive maintenance into an organization. It consists of three layers, which are all important in implementing prescriptive maintenance strategy to an organization's production. Each layer is divided into five different steps, which are all deeply analyzed in specific order. It also has two different dimensions, which are affecting the implementation of prescriptive maintenance. If the maturity

of these dimensions increases, the implementation is possible. (Nemeth et al. 2018) The maturity model is presented in the figure 8.

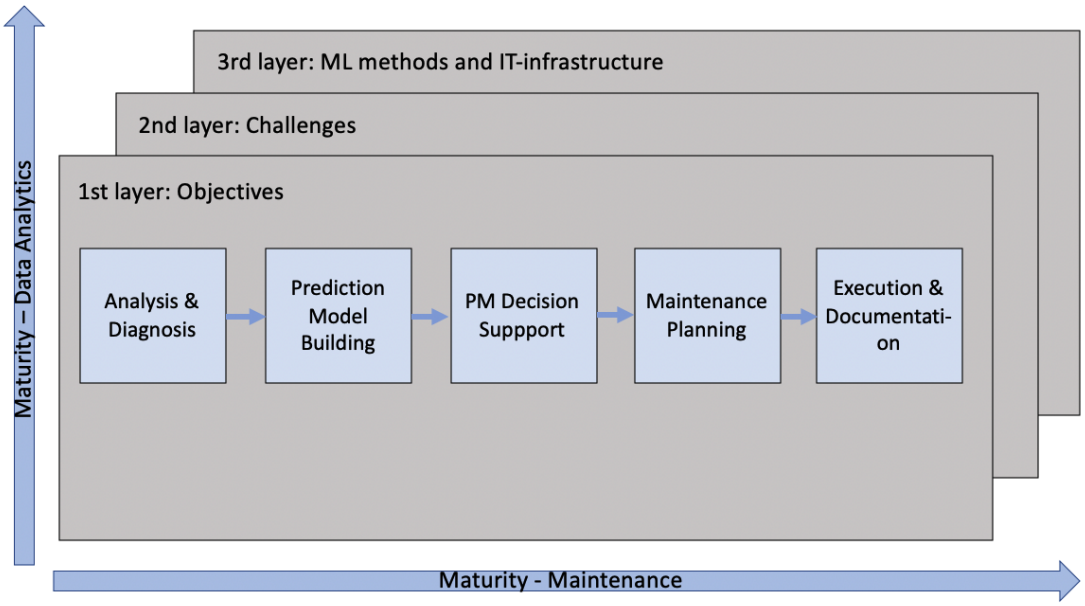

Figure 8. *Maturity model for implementation of prescriptive maintenance strategy (adapted from Nemeth et al., 2018)*

As we can see from the figure 8, the maturity model for implementing prescriptive maintenance is quite complex. The three layers, objectives, challenges and machine learning (ML) methods with IT-infrastructure, all include the steps presented there in the first layer. The steps are done in order to analyze the situation at hand at each layer. The process proceeds iteratively, repeating different steps. When the steps are all done and iterative process has been finished, the prescriptive maintenance strategy can be implemented. As the process itself increases the maturity of maintenance and data analytics, this maturity model is very effective in increasing the capabilities of an organization. (Nemeth et al., 2018)

3.3.2 Maturity model for data-driven manufacturing

In chapter 2, a data-driven maintenance approach was briefly discussed. As the industry 4.0 concept means using technological solutions in manufacturing equipment, data-driven maintenance and data-driven manufacturing can be seen working in a similar way. Both of these use data and information to control and develop the production in manufacturing companies, which means that the basic ideas are very similar. (Ranade, 2019) That's why it is possible to use maturity model for data-driven manufacturing here as a referencing point to maintenance's needs.

Weber et al. present in their article (2017) a maturity model for IT architectures in data-driven manufacturing. This model is presented in the figure 9.

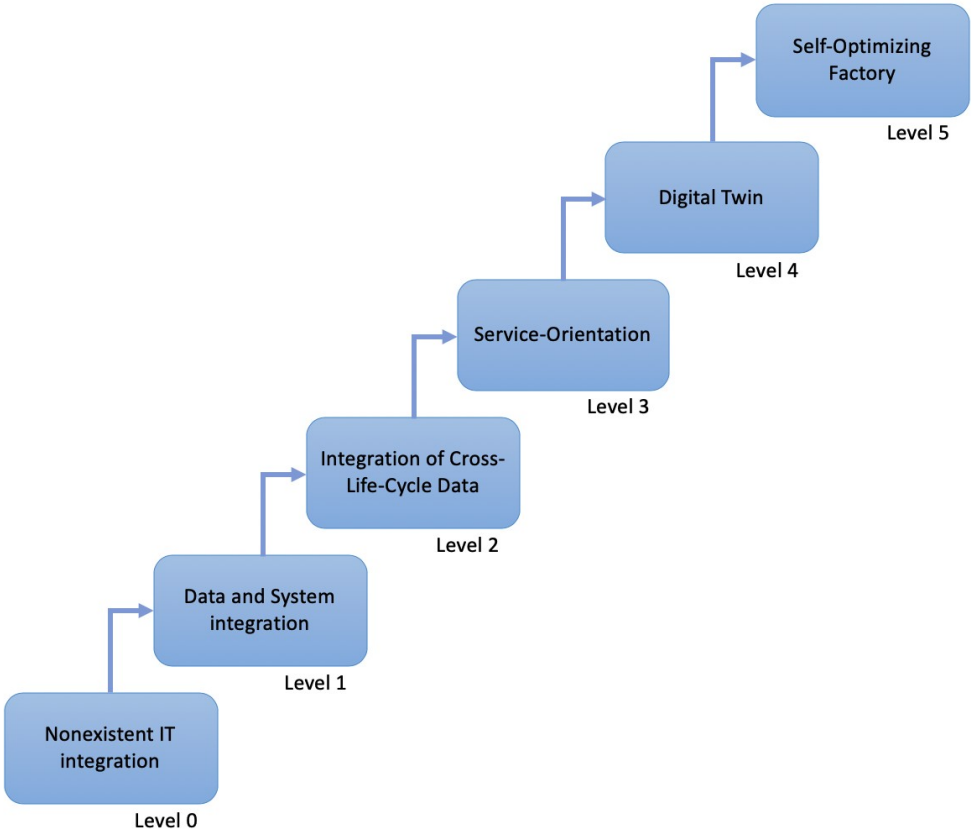

Figure 9. *Maturity model for Data-Driven Manufacturing (adapted from Weber et al., 2017)*

As we can see from the figure 9, the model uses hybrid-like approach, where the model is not either typical maturity grid or a CMM-like step model. The model focuses heavily on data and information technology integration in manufacturing. This model consists of six different maturity levels, where the lowest level is 0 and the highest level is 5. The lower level requirements must be fulfilled in order to develop to a higher level. (Weber et al., 2017)

On the level 0, nonexistent IT integration, any manufacturing machine, tool or other equipment is not integrated with IT. All work is done manually, and, for example, error detection is in the hands of employees. Level 1 is called data and system integration. There, manufacturing machines are integrated and managed by information system as well as the manufacturing work orders. Data is being collected from products and operations, and is being transferred to a repository, where it can be used in, for example, reporting. (Weber et al., 2017)

The level 2, integration of cross-life-cycle data, includes the manufacturing-relevant data and integrates it with other data from the business. That other business-related data can be, for example, data from logistics or after sales. On the level 3, service-orientation, a concept of service-oriented architecture is implemented. This means that the data between different information systems is integrated and exchanged via technological solutions. (Weber et al., 2017)

On the level 4, which is called digital twin, the real-time conditions of all manufacturing assets are placed on information systems and data models. This is used to support decision-making that is based on data and information. On the last level, self-optimizing factory, all information systems, devices and data from the entire product life cycle is integrated. That information is being used to automatically optimize the manufacturing processes within the organization. Real-time and advanced analytics are implemented, and all the manufacturing operations are data-driven. (Weber et al., 2017)

When the last level has been achieved, the maturity of IT architectures can be seen as fully developed. The capabilities of a manufacturing organization have increased to a level, where it is fully mature and cannot develop any further. (Weber et al., 2017)

4. RESEARCH METHODS

This chapter introduces the used research methods and methodology in this study. Firstly, a theoretical starting point for methodology is introduced with research philosophies, approaches and strategies. The target organization of this study is then introduced, as well as the ways of collecting and analyzing data. To be able to create an overview where the target organization is and where they want to be in the future, interviews and a workshop need to be conducted. The data collected from those has to be analyzed, and the process for that is presented last.

4.1 Research methodology

Research methodology examines the reasons behind the used methods of collecting information in researches. When methods are used to collect that information and data, methodology studies that are the chosen methods justified for the research at hand. Methodology always speaks out on what kind of notions are used to understand the reality, in order to get scientific information as a result from the research. (Tuomi & Saarijärvi, 2018, p. 14)

Saunders et al. introduce a concept of research onion in their book (2009, p. 108). That onion consists of different integrities that are crucial in conducting researches, and it creates a base for the scientific framework of different researches. The onion model, which is modified specifically for this study, is presented in the figure 10.

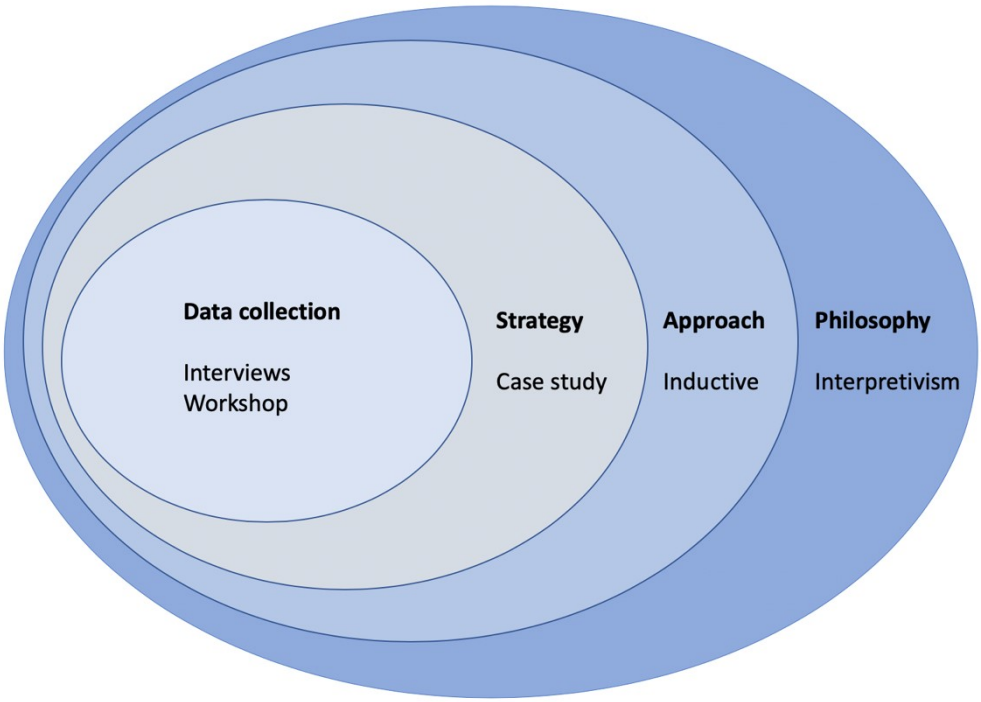

Figure 10. *Research onion in the context of this study (adapted from Saunders et al., 2009)*

As we can see from the figure 10, there is a specific research philosophy, approach, strategy and way of collecting data selected for this study. This research methodology is presented next starting from the farthest shell of the onion model.

4.1.1 Research philosophy

Saunders et al. present four different research philosophies in their book (2009). The philosophies are positivism, realism, interpretivism and pragmatism. Research philosophies are concepts that give guidelines for conducting different researches. With the help of the philosophies, the research gets starting points for data collection, analyzing and using the data. Thus, they are highly related to different ways of using information during the time of research. (Saunders et al. 2009, pp. 107-109)

This study uses interpretivism as the research philosophy. Basically, interpretivism means interpretative basis for doing research. Philosophically interpretivism means making different interpretations about the world and all sorts of subjects. It emphasizes the subjective view of a person, who has made their own interpretations of different matters. Thus, when interpretivism is linked to the research environment, it emphasizes the researchers' subjective interpretations of the subjects they are dealing with. It gives a starting point for a research in a way that the researchers can interpret the essential matters

from the information that is available, and make their own conclusions based on that. (Saunders et al., 2009, pp. 115-116; Curry, 2018) This is the philosophy that is being followed in this study, and the research approach and strategies are aligned with it.

4.1.2 Research approach

The extent one is planning to use theory in a research depends on a research approach. According to Saunders et al. (2009, pp. 124-127), there are two different research approaches; deductive and inductive research approach. When using deductive research approach, researchers must develop a theory and hypothesis, and test it in the research environment. Inductive research approach focuses on collecting data and information and developing theories based on the analyzed data. (Saunders et al., 2009, p. 124) In short, deductive approach tests the theory and inductive approach builds the theory within a research.

This study uses inductive research approach. As Saunders et al. suggest, inductive approach should be used when the study sample of subjects is moderately small, and the focus is on the context of the case that is being researched (Saunders et al., 2009, p. 126). As this study is a research about a specific problem in one organization, and the purpose is not to test or create theories, inductive research approach is the best option from the different approaches.

4.1.3 Research strategy

Research strategy is a plan on how to conduct a research. Choosing the right strategy for the research at hand enables the researches to conduct the research in a systematic way. These strategies help to answer to the research questions, which should have been created before choosing the strategy. (Saunders et al., 2009, p. 141) There are multiple different research strategies that could be used when conducting a scientific research.

Saunders et al. (2009, pp. 141-150) introduce seven different strategies for conducting a research; experimentation, survey, case study, action research, grounded theory, ethnography and archival research. The research philosophy and research approach affect the choosing of a research strategy, since the differences in ways of collecting information and using theory differ among the different strategies. (Saunders et al., 2009, pp. 141-150)

As this study uses the interpretivism as a research philosophy and inductive research approach, the amount of available research strategies is narrowed down (Saunders et al., 2009, p 141). Therefore, this study uses case study as a research strategy. More

specifically, this study uses a single case study as a research strategy, since the focus is on one organization and developing a specific area of business. Case study is defined as “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Farquhar, 2012). This study focuses on finding understanding about the context and uses the information collected to argue the research questions. Thus, the usage of case study as a research strategy is justified. (Saunders et al., 2009, pp. 145-146)

4.2 Target organization

The target organization of this study is a global furniture manufacturer based in Finland. It has over 300 employees in multiple different countries and it has customers in almost all continents. The company’s turnover in the year 2019 was over 100 million euros and it has grown in the past years very rapidly.

This rapid growth has been a result of investments to the sales but has led to a situation, where the already sold products have been left without further attention. Maintenance and the whole of after sales operations have not been the key focus areas, which has generated the current circumstances. The company wants to make a change to this and focus more to the development of after sales before it is too late. Since the products they have sold first are coming to the end of their life cycle in the near future, they have to establish a working maintenance service and implement that into a part of the business.

The company aims to establish a maintenance business but wants it also to be predictive in the upcoming years. They want to provide a world-class customer experience, and that’s why it is necessary for the organization to know the needs for maintenance or service before the customer even notices it themselves. As furniture business is usually considered as a maintenance-free business sector, the company must first make their customers realize that the products need maintenance. By doing that, they will change the whole market and create new business out of maintenance, which is not commonly associated with furniture.

4.3 Empirical study

To be able to conduct a research, data and information about the subject needs to be collected. It is common in single case studies to collect data using interviews as a method. That method is empirically effective, since there is only single organization and usually only one problem that the research is made to solve. With interviews, it is possible

to collect mainly qualitative data, which is then analyzed and used in solving the research objectives. (Saunders et al., 2009, pp. 145-147, 318-320; Farquhar, 2012)

This study uses interviews and workshop as a method of collecting qualitative and quantitative data from the target organization. As the objective of this study is to research the current and target state of the company regarding maintenance with the help of maturity models, both qualitative and quantitative information is required.

4.3.1 Interviews

According to Saunders et al. (2009, p. 320), there are different ways of conducting interviews. Depending on their formality and structure, there can be, for example, structured, semi-structured or unstructured interviews. Structured interviews are based on a strict, beforehand planned structure, which should be presented to the interviewees. The planned question set should be identical in each interview to get the desired results. (Saunders et al., 2009, p. 320)

Semi-structured interview consists of different themes and few beforehand thought questions. The interviewee has a chance to answer more widely and the amount of qualitative information can be a lot larger than in structured interviews. This semi-structured interview approach gives also an opportunity to bring out more thoughts from the whole area that is being researched, since the conversation in the interview situation is admitted to change. The unstructured interview method is the most informal interview method. The interviewer should have an idea of the subject but no predefined questions to guide the conversation to any subject. (Saunders et al., 2009, pp. 320-321)

This study uses semi-structured interview method as a tool for collecting data. The purpose of the interviews is to define the current situation in the target organization using maturity models. As the maturity model and its basic idea is based on the maturity levels, the information about the current maturity level is quantitative. With semi-structured interviews, it is possible to get also qualitative information about the reasons why the target organization is at a specific maturity level. For this study, there are 15 professionals from different organizational units interviewed, which suits well for the desired amount usually used in case studies. There are only the interviewer and one interviewee contributing in each interview situation, in order to get the best and most realistic picture that is possible.

4.3.2 Workshop

Another method for data collection used in this study is workshop. Workshops are creative events, where a moderately small group of people discuss or do something practical around one particular subject. The idea is to create something new or share information between different people. Usually, they include different methods that are used for different causes. (Alston, 2019)

In the workshop for this study, the idea was to make professionals from different organizational units to discuss with each other in order to get the desired result. Methods of larger group conversation and small group working were used in there. The workshop was used to collect qualitative data about the target maturity state of the company, and to find out the possible solutions to achieve those targets.

4.4 Data analysis

As the main method of collecting data was interviews, the information gained was mostly qualitative. Saunders et al. (2009, pp. 480-482) present different tools for analyzing qualitative data. The starting point of analyzing qualitative data is transcribing the collected data. From that data, common subjects and observations should be found and documented for further, more detailed analysis. The data should be then analyzed with the chosen methods and taken into the research. (Saunders et al., 2009, pp. 480-482, 485-495) The process of data analysis for this study is presented in the figure 11.

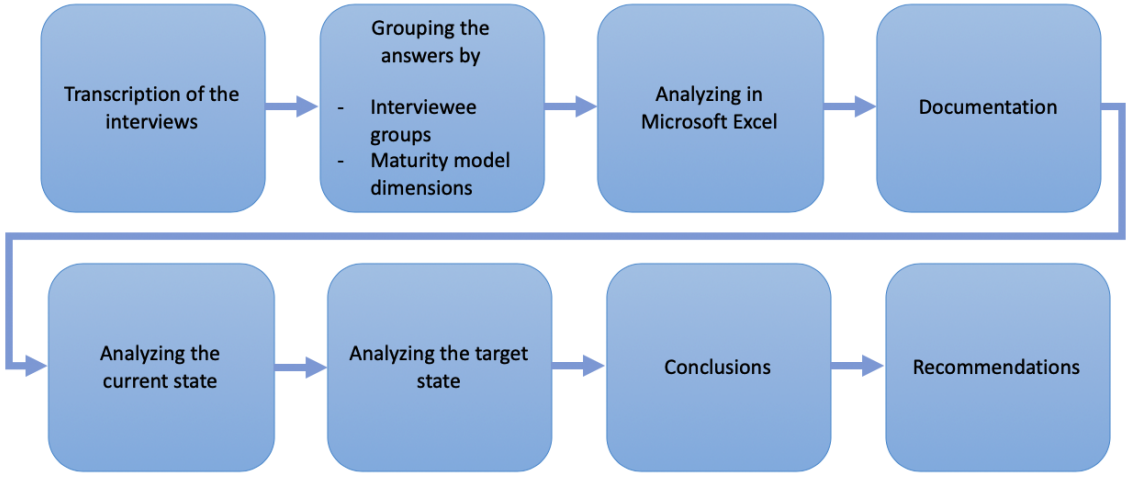

Figure 11. *Process of data analysis in the study*

The data analysis started with transcription of the interviews. All the interviews were recorded, so the recordings were listened and transcribed. The answers were then grouped

by the interviewee groups, in which the group A consisted of professionals working directly with maintenance-related issues, and the group B consisted of professionals from other organizational units. The answers were then analyzed in Microsoft Excel and documented. The current and target maturity levels were then analyzed. Afterwards, conclusions, which can be found from the chapter 7, and recommendations as well as a possible plan for future were conducted.

5. CUSTOMIZED MATURITY MODEL

As stated in the previous chapters, maturity models should be customized to fit the needs of a case or a company. In this study, a maturity model has been created to fit the needs of a company that is establishing maintenance business in addition to its core business. In this chapter, the process of creating and customizing maturity model is introduced, as well as the maturity model itself. The model is explained in the chapter 5.2. and the dimensions and maturity levels are introduced in that chapter's subchapters.

5.1 Customization process

As mentioned already in the chapter 3, there are different ways for developing maturity models. The generic framework by de Bruin et al. (2005) was the model chosen for this study. That framework was followed in the development process of the customized maturity model. Also, the procedure development model by Becker et al. (2009), was influencing the development process, since their model emphasizes the importance of iterative operations. These models are basically aiming for either business development or IT development, which suit the idea of developing predictive maintenance business perfectly. As the predictive maintenance is based on data and information, it is possible to use these development frameworks and models for customizing the maturity model for that cause.

The customization process started by having a meeting with the target organization. As the first step in de Bruin's et al. (2005) development framework is defining the scope, that was the first step in this development process as well. In the discussion with the target organization it was decided that the focus would be only in developing and creating predictive maintenance business processes for the company. This means that the subjects were narrowed down to only one larger entity, and the scope should be only there.

After the scope had been decided, the second step in de Bruin's et al. (2005) model is determining the design of the model. The target audience was selected, which in this study is an internal organization, since the target is to develop and establish new business for the target organization. The needs of the company were also discussed, and the result was that the company would use the maturity model in developing and establishing the maintenance business.

Designing the maturity model was the second phase, and the third phase is deciding the contents of the model (de Bruin et al., 2005). As the maturity model should focus on

predictive maintenance-related issues, a lot of different subjects should be considered. As predictive maintenance is leaning heavily on data and information, analytics and IT, these would be the key points in the maturity model. It was also discussed that the processes, organization and the needed skills for the development work of maintenance should be integrated into the model. All these subjects contribute to the predictive maintenance, and by developing them the company is able to improve their capabilities.

Once the contents of the model had been decided and filled up, the maturity model had to be tested. As de Bruin et al. (2005) mention, the possible mistakes can be found via this method. The testing of the maturity model for this study was done simultaneously with the interviews. The maturity model was iteratively evaluated, and changes were made to it even before that, as in the development framework by Becker et al. (2009). However, the real testing of the model happened during the interviews, when the professionals from different organizational units had the chance to evaluate the current situation in the company. Related to the feedback gotten from the interviews, few changes were made to the maturity model.

As the maturity model is used in this study to develop the predictive maintenance business, the fifth and sixth phase of de Bruin's et al. model (2005), deployment and maintaining, are not possible to evaluate at this point. The deployment is happening as this study is published and maintaining should be done after the maintenance development process has started in the first place.

In the development process of this maturity model all the dimensions and subdimensions, as well as the common maturity levels and the maturity level for each dimension were customized. The two maintenance-related maturity models, which were introduced in the chapter 3, were used as a reference to define all the customized parts. Firstly, the Knowledge-Based Maintenance (KBM) model guided the scale of the maturity levels of this model. The KBM model introduces four different maintenance strategies from descriptive maintenance to prescriptive maintenance (Nemeth et al., 2018). As the target organization is not pursuing to develop prescriptive maintenance, that KBM model was scaled down. Therefore, the common maturity levels for the model used in this study vary from descriptive maintenance to predictive maintenance. The five common maturity levels were set between those strategies to be able to determine the maturity levels of the different dimensions.

In this maturity model, all the five dimensions that are affecting maintenance development have their own customized maturity levels. As mentioned, the maturity levels are defined in a way that, for example, level 2 is the same in each of the dimensions, although

they have dimension-specific descriptions. The contents of the dimensions were decided in the discussions with the target organization, but a maturity model by Oliveira & Lopes (2019) was also used here. The subdimensions, which are a part of the main dimensions, were also decided in the discussions with the organization. The subdimensions consist of different matters that are strictly related to the main dimensions. The organization wanted to point out those matters in order to remember their existence and see all the subjects that will affect the development of predictive maintenance business.

5.2 The customized maturity model

The result of the development process, a customized maturity model for predictive maintenance business development, is presented in the figure 12.

Maturity level	Data & analytics	Technology	Organizational culture	Organization & processes	Skills & abilities
1					
2					
3					
4					
5					

Figure 12. *Customized maturity model.*

As we can see from the figure 12, the maturity model consists of five different dimensions and five maturity levels. The dimensions are data & analytics, technology, organizational culture, organization & processes and skills & abilities. All these subjects were identified to affect the development of predictive maintenance and therefore they are presented in the model.

Data and analytics, as well as technology, are used to support predictive maintenance business. As stated in the previous chapters, the predictive maintenance relies heavily on data collected from the products with technological solutions. This means that these sectors should be highly developed in order to provide functional predictive maintenance to customers. The organization and processes for maintenance are crucial in the execution of maintenance business, as they create the ground rules that should be followed whenever maintenance operations are done.

Organizational culture is one of the key elements in different development projects. As the target organization has not been focusing on maintenance earlier, it is crucial that the employees are informed about it and culture around it is created. The attitudes of employees are critical in order to make maintenance a part of the everyday business within a company. This also links to the skills and abilities, which are obviously very important in succeeding in the development of maintenance. Skillful and professional people with right know-how are able to develop different processes and subjects around maintenance.

These are the reasons why the different dimensions were chosen for the maturity model and are used in evaluating the current situation of maintenance in the target organization. The maturity levels, varying from 1 to 5, were created based on the previously mentioned reference models. The common maturity levels are presented in the table 2.

Table 2. *Common maturity levels of the customized maturity model*

Maturity level	Level name	Level description
1	Descriptive maintenance	The organization has no clear processes for maintenance.
2	Semi-diagnostic maintenance	Some processes for maintenance, but they are poorly developed.
3	Diagnostic maintenance	Clear processes for maintenance, but a lot needs to be improved.
4	Semi-predictive maintenance	Maintenance processes are advanced, but there are still things to improve.
5	Predictive maintenance	Maintenance processes are fully developed, and the organization is providing maintenance to customers before they know they need it.

These common maturity levels are describing the levels of the dimensions in the real maturity model and they create a base for the individual levels. With these common maturity levels, it is possible to make the intervals between different maturity levels equal in each dimension and make the levels match so that, for example, level 3 is similar in each dimension.

As we can see from the table 2, the common maturity levels focus on the development of maintenance processes and on the capabilities of providing maintenance for customers. As the level increases, the maturity and the capabilities of the target organization increases. At the descriptive maintenance level, the company is not able to provide any maintenance services to their customers, as they do not have the capabilities to do so. The organization does not have any processes for maintenance developed, and the maturity can be seen to be at its starting point. On the second maturity level, semi-diagnostic maintenance, the company is able to provide some kind of maintenance to their customers, but there is not coherence in different processes at all. Maturity can be seen to be developed a little bit, but the capabilities are still very poor.

The diagnostic maintenance means that the company is able to provide maintenance based on the previous maintenance services done to particular customers. There are clear processes, which guide the execution of different operations and enable the maintenance overall. The maturity can be seen to be developed to halfway, as the company is providing maintenance, but not based on information collected. At semi-predictive maintenance maturity level, the company can be seen to be offering maintenance related some kind of data, which is not fully developed. The processes are advanced, and technology is used in different maintenance operations, but the actions cannot be still considered as predictive. The maintenance can be seen to be highly developed, but it has not still reached the full potential. At the last maturity level, the maturity can be seen fully developed within these frames and is not able to advance further. The organization is able to provide predictive maintenance, which is based on real-time information.

The dimensions of the maturity levels needed more clarification, and therefore subdimensions were defined. All of the five dimensions include two or more subdimensions, which are subjects that are strongly affecting the development of each dimension. The dimensions and their subdimensions are presented in the figure 13.

Data & analytics	Technology	Organizational culture	Organization & Processes	Skills & abilities
Data quality	Information systems	Knowledge sharing	Organizational structure	Technological skills
Data management	Integration	Incentives	Relationships between stakeholders	Management skills
Data acquisition	Devices	Flexibility & change acceptance		Analytical skills
Visualization and reporting				

Figure 13. *Subdimensions of the maturity model*

As we can see from the figure 13, there are a lot of different aspects in each dimension, and all of them must be developed in order to increase the capabilities of the company. The aim is to develop predictive maintenance business and therefore all these aspects must be taken into account.

All these subdimensions were determined in discussions with the target organization. Different objects of development were already recognized beforehand, and that is why they needed to be included in the maturity model. The previously mentioned maturity models for prescriptive maintenance development and maintenance performance development were also used in identifying the key development areas for predictive maintenance.

All dimensions have also their own maturity level descriptions, which guide the development of each area. The maturity levels are linked to the common maturity levels, as already stated above. These dimension-specific maturity model descriptions are aligned so that at a certain maturity level the capabilities of the company match the common maturity level description. For example, if the target organization reaches the level 3 in every dimension, it could be stated that the maintenance within the company is diagnostic and the maturity is developed to halfway of its full potential. All the requirements at a certain maturity level must be achieved in order to step forward to the next maturity level and develop the capability of the company.

These different maturity model descriptions include the subdimensions of the maturity model in each of the maturity levels. In that way, the maturity of a certain dimension can be evaluated in a correct manner. The dimensions and their customized maturity level descriptions are explained thoroughly in the next subchapters.

5.2.1 Data and analytics

Data and analytics dimension consist of four different subdimensions. There are a lot of aspects that affect the data and analytics of maintenance and that's why they need to be addressed in the model as well. The identified subdimensions are data quality, data management, data acquisition as well as visualization and reporting of data.

Because predictive maintenance relies heavily on data analytics, this dimension is one of the most important ones in the maturity model. It is slightly dependent of another dimension, technology, which eventually enables the usage of data and information.

Level 1: Data is acquired from few sources and the quality of data is poor. There are no systematic processes of collecting, using or storing data, and it has no ownership. Data is not used in reporting or decision making at all.

Level 2: Data is acquired from multiple sources, but it is stored in people's own storages. The quality of data is quite low, but it is used in simple reports. Data does not have an owner.

Level 3: Data is acquired from multiple different sources and stored into information systems. It has an owner and the quality of the data is quite good. It is combined with other data and being used in reporting and decision making.

Level 4: Data is acquired from various sources and with the help of technological devices. It is stored into a repository where it can be used and combined with other information. The quality of the data is good, and it is used in reporting. The data repository has an owner who manages the data.

Level 5: Data is acquired in a systematic way using technological solutions in products. It is stored into a warehouse, which has an owner and where it can be used and combined with any business-related information. The quality of the data is very high, and it is being used in reporting and it supports decision making of maintenance processes.

5.2.2 Technology

The technology dimension of the maturity model consists of three different subdimensions. It takes into account the current and possible future information systems that are necessary for the maintenance to be predictive. The devices that can help gather data straight from the products in a preventive way are also a part of this dimension. Integration between these devices and different information systems is also necessary for the whole process to work in a way the target organization wants.

This technology dimension is related to the data and analytics dimension because of the ways of collecting data and using data in a useful manner. Information systems and the usage of them is needed to provide, for example, advanced reports and analyses about maintenance.

Level 1: No information systems in use. Products have no technological devices that could be used in creating new business or collecting data.

Level 2: Enterprise Resource Planning (ERP) system is being used in maintenance processes. Few products have devices that can help acquire data.

Level 3: ERP system is integrated with other information systems that are used to support maintenance processes. Technological devices that help gather information have been attached to one product family completely.

Level 4: All current information systems are integrated with each other and information can be used in the maintenance process. A new information system for maintenance organization has been acquired. Almost all products have technological devices that can help in gathering information.

Level 5: Maintenance is heavily based on information gained from technological solutions, such as sensors, that are attached to all products. In the sales process, the company has a possibility to provide maintenance services based on information collected from technological devices. Maintenance organization has its own information system which is integrated with ERP and sales information systems.

5.2.3 Organizational culture

Organizational culture addresses the need for a change in the target organization's mindset and a cross-organizational collaboration for the maintenance to succeed and to become a part of the everyday business. It takes into account knowledge sharing, which is crucial both inside the maintenance organization but also in the whole organization as well. It also addresses how flexible and positive for changes the organization is, and the incentives, which must be clearly set for the people working with maintenance.

Level 1: Information is very siloed and for example in employees' own emails where it is not shared with others. Attitudes towards maintenance and its processes are negative and only few people are working with them.

Level 2: Information is shared among a small group of people and others do not have access to it. Maintenance is seen as a mandatory part of business and no further development of it is seen useful.

Level 3: Information is shared between different organizational units and there are clear processes of doing that. Attitude towards maintenance is neutral and it has become a part of the business.

Level 4: There are no information siloes between organization and processes are working as they should. Maintenance is a part of the business and there are resources to develop it further.

Level 5: Information is shared between different organizational units and is being used to support decision making and monitoring of the maintenance processes. Maintenance is in a key role of business and is seen as a competitive advantage. Incentives are clear and they are part of the process.

5.2.4 Organization and processes

The key point in the organization and processes dimension is the way of organizing the whole maintenance business. The processes must be defined in order to offer predictive maintenance services to customers. This dimension consists of two subdimensions. It takes into account the structure of the maintenance organization, which is crucial in executing maintenance operations. It also includes the relationships between stakeholders, as the target organization aims to provide maintenance through different channels and other companies.

Level 1: There is no maintenance organization and no ownership of any maintenance processes. Maintenance is done locally by customer requests with no automation or clear process. There are no partnerships established and everything linked to maintenance is done ad hoc.

Level 2: Maintenance organization is focused around one person who handles all maintenance needs. Maintenance is still done by customer requests, but in cooperation with subcontractors or partners. No clear processes have been established.

Level 3: Maintenance organization is established within the company and customers have a chance to fill a maintenance form to request service. There are multiple different partners who can handle the maintenance around the world. Maintenance process exists but is not coherent all over the world.

Level 4: There is a maintenance organization which can handle maintenance requests. Customers have a possibility to fill a form to get service, or maintenance is done by reaching out customers by the company based on the information gained from the products. Maintenance network works in multiple countries and the process is similar everywhere.

Level 5: Clear maintenance organization structure within the company with leader and ownership. Maintenance is done before customers even know they need it because of predictiveness and clear processes. The company has a possibility to provide customers a maintenance package which is sold simultaneously with the product. Global network is established with multiple partners all over the world.

5.2.5 Skills and abilities

The skills and abilities dimension is about the people in the organization. It takes into account different skills the employees have and should have when implementing the maintenance operations. Technological, analytical and management skills were the most crucial skill identified to establish and start offering predictive maintenance business.

Level 1: There are no capabilities to run maintenance business or maintenance organization. There is no leader of maintenance business and no maintenance organization. Technological and analytical skills are not at the required level. The company does not identify the need of skills and abilities.

Level 2: Maintenance business is done by few individuals, who do not have the needed skills to run it. There is a named person to run the maintenance business but not clear maintenance organization. The company is able to create simple reports regarding maintenance and use simple technologies to collect data. More recruitments are needed but the needs are not quite well identified.

Level 3: Maintenance business is done by an organization that has skilled employees and a leader. The need of skills and abilities are identified, and recruitments are done actively. The company is able to create more developed reports and analyses with data collected from technological solutions. Training and development of current employees' skills about maintenance are not provided by the company.

Level 4: There are a broad sector of skills and abilities in the maintenance organization. No recruitments are needed, but competent people are still being searched. The company is able to produce reports and analyses that help in decision making, and the technological know-how is at high level. Training and development of employees' skills about maintenance are provided by the company.

Level 5: Every business sector has skilled and motivated people who are capable to develop maintenance processes and are willing to help the maintenance organization. The employees are able to understand the customer needs of maintenance proactively. Analytics and technology support maintenance heavily with information that can be used in a predictive way. Training and development of employees' skills are provided by the company actively.

6. RESULTS

After customizing the maturity model to suit the target organization's needs, interviews were conducted. The purpose of these interviews was to find out the current state of maintenance in the company and see the reasons behind. There were 15 interviewees, which were selected around the organization in a way that their expertise matches with some of the dimensions of the maturity model. The results from the interviews can be found in chapter 6.1.

After the interviews, where the target state of maintenance in the company was set, a workshop was held. The purpose of the workshop was to figure out short-term and long-term objectives with a group of professionals, who are going to work with maintenance business in the future. The results and the target state of maintenance in the company is stated in the chapter 6.2.

6.1 Current state of maintenance in the company

Interviewees were asked about the current maturity level of the maintenance to find out the current state of it. They were also asked to comment why the situation is what it is and what are the reasons behind. The interviewees were asked to evaluate the maturity level of different dimensions only from the maintenance perspective, for example, only maintenance-related data or processes.

The interviewees' answers are divided into two groups because of unawareness and different biases of the professionals. Group A consists of people that are closely working with maintenance either now or in the future and have knowledge of the whole field. Group B consists of people that are experts in another field, for example in data analytics or human resources.

Interviewees' names and titles are hidden in this study to make them unrecognizable so that no one have biases towards their answers. They also have abbreviations to make the analyzing and quoting easier. For example, interviewee number 6 from group A is shortened I6A, and interviewee number 2 from group B is I2B.

6.1.1 Data and analytics

The current state of data and analytics based on the answers of group A can be seen in the figure 14.

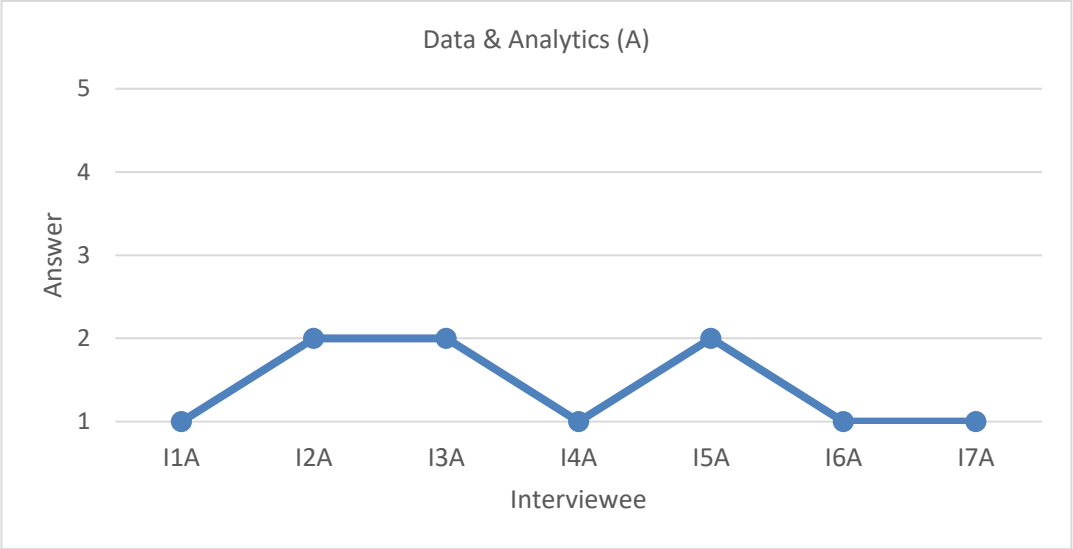

Figure 14. *The current maturity state of data and analytics dimension by group A*

The current state of data and analytics based on the answers of group B can be seen in the figure 15.

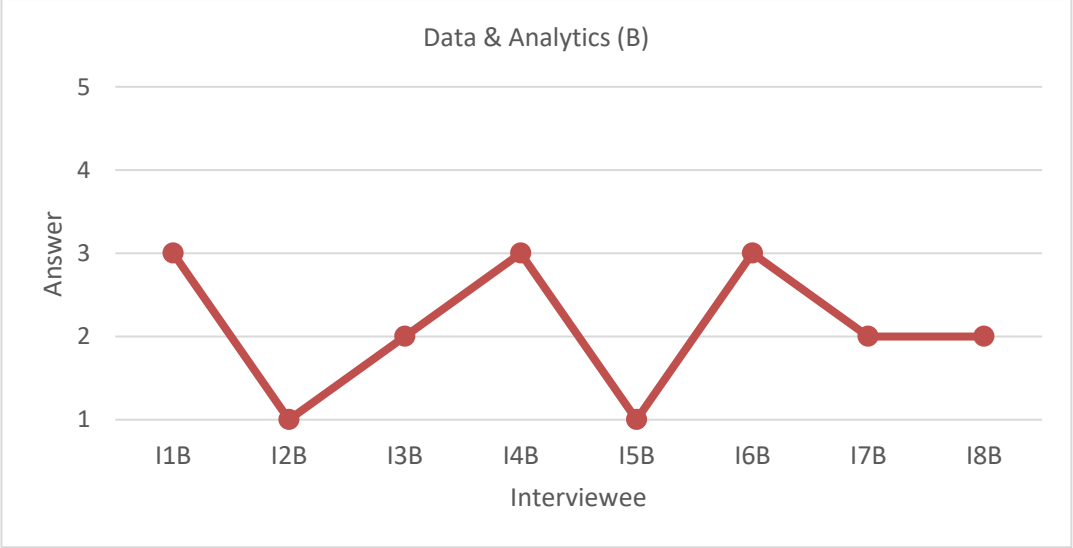

Figure 15. *The current maturity state of data and analytics dimension by group B*

As we can see from the figures above, the answers vary quite a lot between different groups. Group A evaluates the current situation of data and analytics to be in between level 1 and 2, whereas group B's answers are much more divided between levels 1 to 3.

The most frequent answer to the reasons behind this current state was that the target organization does not have any systematic ways of collecting, storing or using the data

gotten from the maintenance and service visits at the moment. Because the company has not been focusing on developing maintenance business, almost everything related to that has been left without attention.

From data quality perspective, almost all interviewees answered that the quality of the current data is very low. Because there have not been any procedures towards maintenance-related data, there has not been a reason to, for example, clean the marginal amount of data collected thus far. The information the company currently gets from maintenance visits is usually hand-written on a paper that is then sent via email to someone responsible for selling the maintenance to a customer. That paper is then left there without any attention, which obviously makes the quality of that data very low and that whole information useless.

Data management is also at bad level according to the interviewees. I1A states that "There is no named person to manage or own maintenance-related data, so everyone working with this [maintenance] handles the information gained in their own way." Data gotten from the maintenance visits could be used in developing products and analyzing the needs for improvements, but when the management is left to the people working with their own ways, these improvements cannot be done.

Based on the answers from both groups, the company's knowledge about their sold products is at a very bad level. They do not have the capability to identify specific products at customer sites, because they do not have knowledge about end customers, sold configurations or installation times. This data and information from already sold products is crucial in developing maintenance business and creating preventive maintenance processes.

As previously mentioned, the target organization has not had any ways of collecting data. I6A says that "The only thing we get, is a hand-written report, which is basically a piece of paper and is not stored anywhere electronically." Another interviewee I3A states that "Basically the information we currently get from service visits are notices and comments from the third-party installers, which do not even use the same terms as we when speaking about our products. It would be my dream to get data straight from our products without any intermediaries." For these reasons, the information is only describing and not purely data that could be used in, for example, reporting or developing the processes.

Because of the above-mentioned reasons, there has not been done any visualization or reporting using maintenance-related data. I5B states that "I have not seen anything linked to maintenance in any reports. I did not know we even do that [reporting] to maintenance data." Many of the interviewees stated that it should be a crucial part of the whole

maintenance process to create reports and use them to recognize needs for improvements in both products and in the maintenance process itself.

Although the answers differ between the groups A and B quite a lot, the reasons behind the evaluated maturity level are quite similar. There were few interviewees from group B that admitted they had no idea about maintenance-related data, which obviously distorts the quantitative information gotten from the interviews. They usually guessed the current maturity level and thought that the situation is better than it really is, because usually the data management and quality of the target organization is at high level.

6.1.2 Technology

The current state of maintenance-related technologies based on the answers from the group A can be seen in the figure 16.

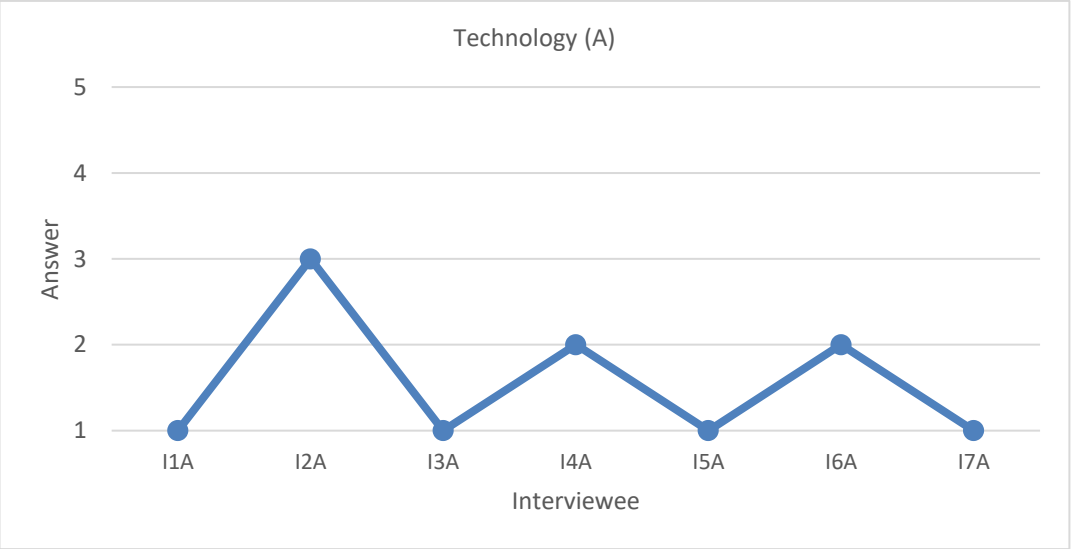

Figure 16. *The current maturity state of technology dimension by group A.*

The current state of maintenance-related technologies based on the answers from the group B can be found from the figure 17.

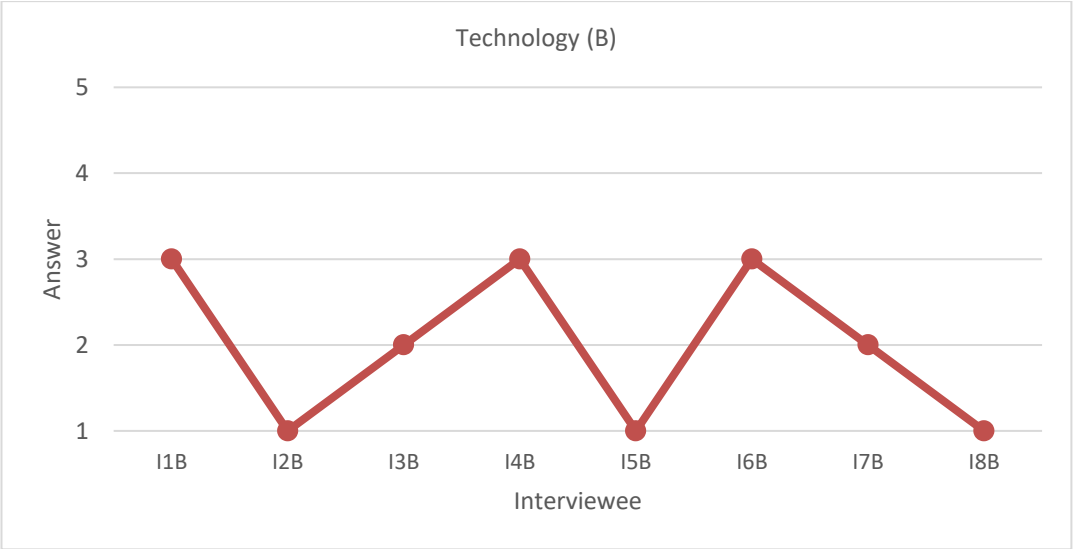

Figure 17. *The current maturity state of technology dimension by group B.*

Technology dimension's current maturity level is evaluated by the group A to be mostly between the levels 1 and 2. group B's answers vary again a lot, and they have evaluated it to be somewhere between levels 1 and 3.

Multiple interviewees were pointing out that some kind of electronical service book or field service management system should be acquired. I7A stated that "We should definitely bring our maintenance process to some kind of information system where we could track the maintenance history of one specific product to see what kind of product it is and what has been done to it previously." The company has not really thought this or compared different solutions for this maintenance information system so far, but the will is to do so.

Currently the company has its ERP system used only in few maintenance-related issues. The billing of currently done service visits and customer management is done with ERP system, which is integrated with the sales information system. To be able to be predictive with maintenance, the company should be able to combine information from different information systems and data collected from the product itself.

Integration was not seen as an issue slowing down the development of maintenance business. Multiple interviewees stated that the current ERP system is integrated with information systems used in sales and in manufacturing. The only concern that was pointed out, was that when acquiring new information system, such as previously mentioned field service management system, the company must ensure that information flows between these different systems and they work as described in the processes.

The devices that could help gather data from the products are only piloted in few current products. Currently, the information gained from there is practically only about utilization,

which is not useful for the company nor the customer. I3A states that “We should have devices that can help gather information straight from our products. Then we should do more testing to our current products and combine that information with the data collected from our products in customer use.” The desire of the company is that they would know before the customer that something is broken or about to break and offer maintenance to that need.

The answers from group A and group B were very similar due to common knowledge that their products do not have devices that could help gather information. Group B evaluated the maturity to be a little bit higher because they did not know anything about the current situation regarding information systems or integration. That information is not crucial or highly relevant to everyone, so the scattering between the groups’ answers is not significant.

6.1.3 Organizational culture

The current state of maintenance-related organizational culture based on the answers from group A is shown in the figure 18.

Figure 18. *The current maturity state of organizational culture dimension by group A.*

The current state of maintenance-related culture based on the answers from group B can be seen in the figure 19.

Figure 19. *The current maturity state of organizational culture dimension by group B.*

Organizational culture's current maturity levels differ a lot between the two interviewee groups. Group A evaluates organizational culture to be at level 1 or 2, but group B evaluates it to between levels 2 and 4. This difference is significant, which indicates that the people from group B do not really understand or have the right information about the current situation of maintenance in the company.

Many of the interviewees from group A stated that currently the company has only a handful of people who really know anything related to maintenance. Information is not shared between different organizational units and even less to the whole company. I4A stated that "Information is currently very siloed because it has not been shared in the organization. People have not been interested in maintenance, because they think our products do not need maintenance at all."

On the other hand, group B thought that everything is going really well in the maintenance organization. That, and also the matter that group B's interviewees could not answer to all questions, strengthens the fact that information is not shared enough inside the company.

Incentives about maintenance are currently non-existent. Many of the interviewees stated that some kind of bonus model or other system should be created for selling maintenance inside the company. It was also stated that the company should think the third-party companies' incentives. The company is planning to use different maintenance companies around the world, which means that they need to motivate them in a way they want to take the best care of their products and create better customer experience for their end customers.

Attitudes towards maintenance have been very neutral or even slightly negative so far in the company. The company has focused only on selling the products as much as they can, and they have not noted the maintenance needs at all. As mentioned above, the company's own employees do not even know that their products might need maintenance. I6A stated that "If we do not realize that our products need maintenance ourselves, how could our customers do so." That mindset should be changed to be able to create a business out of maintenance. The company's management team has stated that they really want to develop maintenance business, which means that now they have started to change the mindset.

This dimension has the most significant scattering between the groups and their answers. The biggest reason behind this is that most of the people from group B thought that maintenance means same thing as reclamations. This is not the case, because reclamations are done when something is already broken, and maintenance should be done before that. The company aims for preferring maintenance, since less amount of reclamations means better brand image and better customer experience.

6.1.4 Organization and processes

The current state of company's maintenance organization and processes based on the answers of group A can be seen in the figure 20.

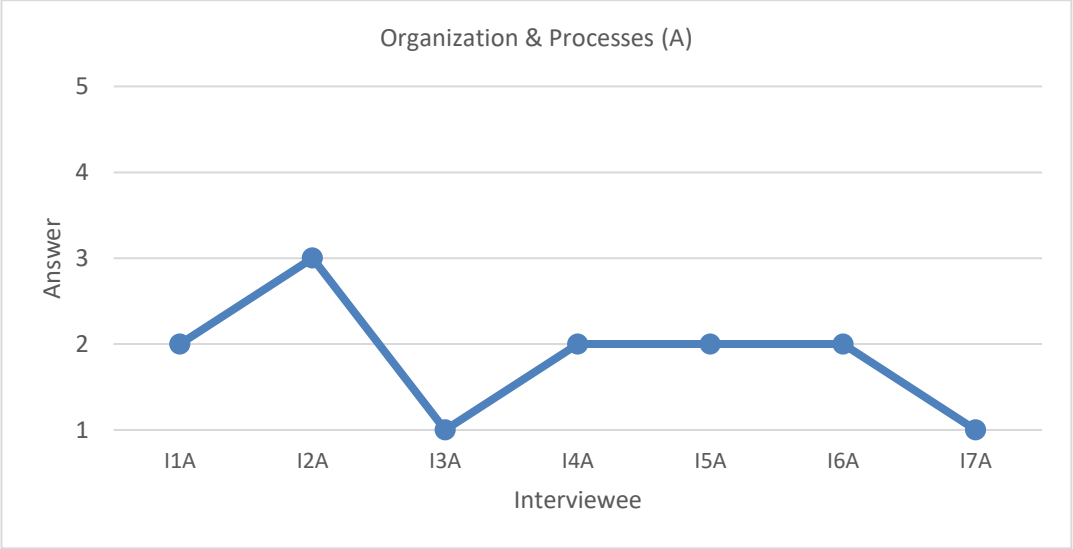

Figure 20. *The current maturity state of organization and processes dimension by group A.*

The current state of maintenance-related organization and processes based on the answers by group B can be seen in the figure 21.

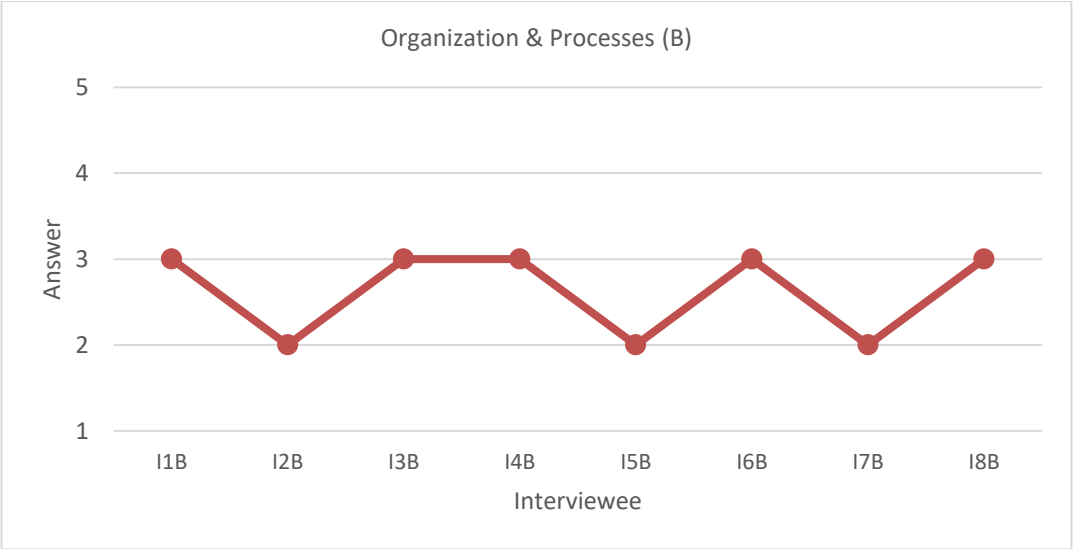

Figure 21. *The current maturity state of organization and processes dimension by group B.*

As we can see from the figures above, both groups evaluated maintenance-related processes to be between maturity levels 1 and 3. Group A's answers were again a little bit lower than group B's, but the difference is not now as big as with other dimensions.

Currently, the company's maintenance organization is really small. I7B stated that "I do not know if we have a maintenance organization or not." They have not developed maintenance at all, so the maintenance team is also very light. It has a manager, but nothing has been really done so far.

When discussing the maintenance processes, almost every interviewee stated that there are not any processes developed thus far. The company is currently doing every maintenance visit case by case, and the process depends on the person who is responsible for that case. The company does not have any possibility to sell, for example, maintenance packages alongside with their products, because all they do is handle reclamations, from which most of them could have been prevented by doing maintenance visits earlier.

Multiple interviewee from group A stated that the company should create a clear process of doing maintenance and modify it in different countries. The company is selling their products all around the world and every country has its own way of doing things. That's why they cannot create a one-size-fits-all solution and they have to develop the business model behind that all and modify it when needed. They also stated that they should probably have different kinds of approaches and solutions for different retailers and end customers.

The company wants to use third-party maintenance companies or their dealers' contacts when doing maintenance visits because they cannot handle them alone. Their products

are on every continent, which means that they have to build a network of different actors around the world. I1A stated that “We should make contracts and deals with few partners and stick to that and not use this here and that there. In a long term, we should focus on finding the right partners to do maintenance for us, and train them ourselves. So that they know how our products are built and what could be the reasons behind some mal-functions.”

The interviewees from both groups gave very similar answers to the questions about their maintenance processes. All stated that there is a lot to improve and develop to create more business from maintenance.

6.1.5 Skills and abilities

The current state of maintenance-related skills and abilities based on the answers of group A is shown in the figure 22.

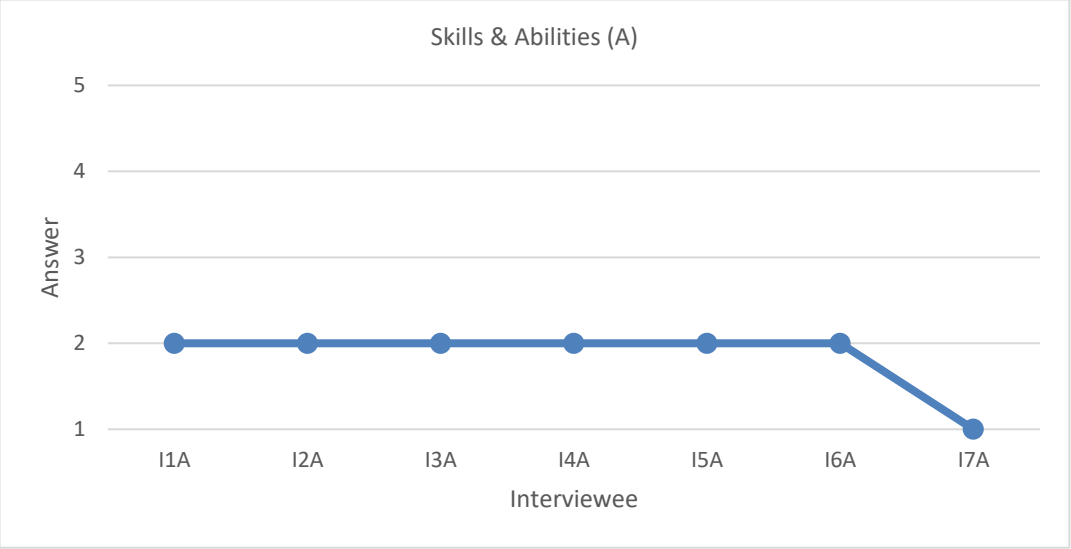

Figure 22. *The current maturity state of skills and abilities dimension by group A.*

The current maturity level of skills and abilities related to maintenance based on the answers from group B is shown in the figure 23.

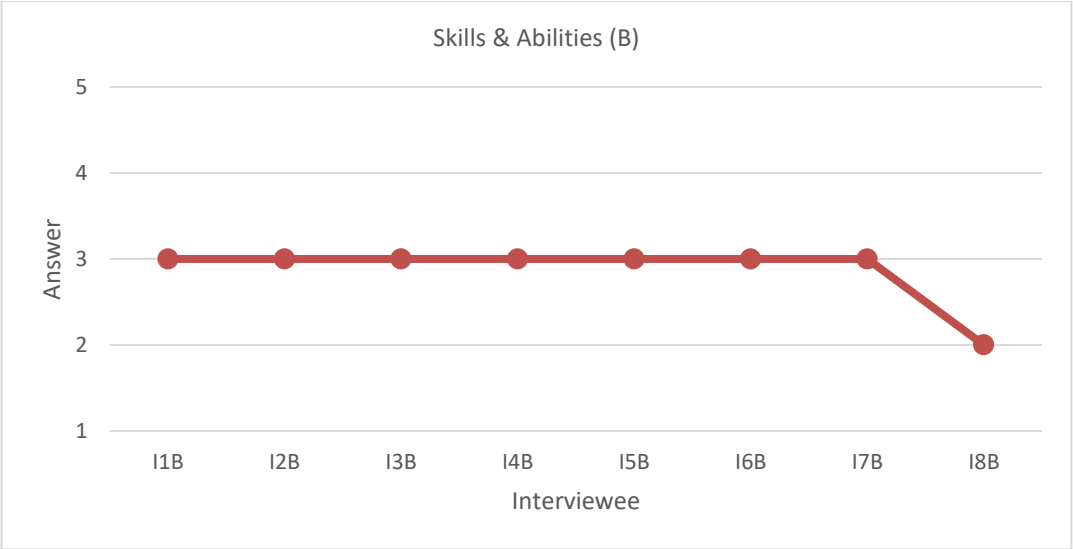

Figure 23. *The current maturity state of skills and abilities dimension by group B.*

As we can see from above, group B's answers are exactly one level above when compared to answers from group A. Group B evaluates the situation to be between maturity levels 2 and 3, and group A evaluates it to be between maturity levels 1 and 2.

One of the biggest things that has slowed the company down in developing maintenance is the lack of resources. Everyone in the group A stated that they do not have enough time to develop processes or think how maintenance should be organized in the future. I6A, who works in a managerial position, stated that "I think we have somehow recognized the needs for new employees. We need them in training maintenance companies, and we need them in creating and developing processes for maintenance. We also need people to proactively offer our future maintenance business for our customers."

The company identifies that they have enough skills to develop maintenance. For example, the analytical skills are very good, but the barrier in front of creating reports or visualizations has been the amount and quality of data collected from maintenance visits. The company has also enough management skills, but the focus has not been on the strategic side where business model for maintenance should have been created. The biggest issue has been resources, which are highly insufficient.

The differences between the group's answers are probably coming from the fact, that group B's employees do not work with maintenance-related issues at all. The people from group A really recognize the situation and the need for extra resources, which will not show outside of the small organization so much. As I5A stated, "If we want to focus on something else than operative working, we need more resources."

6.2 Target state of maintenance in the company

The target state of maintenance in the company was decided in a workshop that was held only for professionals from group A. They are working with maintenance-related issues on a daily basis and will be working in developing the maintenance business in the future. That is the reason only they were invited to the workshop to decide short-term and long-term targets.

In the workshop, short-term targets were set with a method, in which the participants were divided into few small groups. They had to evaluate the situation and set a target state with clear arguments. The target levels should be really achievable by the company and that's why they needed to be realistic. After their own suggestions, the different groups discussed with each other and decided only one target maturity level for each dimension.

The long-term target state was decided in the same workshop but with group discussion. Because the long-term target is the ultimate objective in the future, only short reasonings were needed for that.

6.2.1 Short-term target state

The main focus of the workshop was to set targets to the near future about the development of the maintenance business. The short-term target means that the maturity of maintenance should be at the level figure 24 shows in nine months.

	Data & Analytics	Technology	Organizational culture	Organization & Processes	Skills & Abilities
1					
2					
3					
4					
5					

Figure 24. *Short-term target maturity state*

As we can see from the figure 24, targets are set to maturity level 3 in every dimension. As the current state is quite low based on the answers from group A, there is a lot to achieve in nine months.

The small groups in the workshop's group working part were asked to tell reasons why the company wants to achieve that particular maturity level, and how that could be achieved. These results are combined and are presented by dimensions next.

Data and analytics

The short-term target maturity level of data and analytics dimension was set to level 3. The participants told that the company's organizational capability to provide maintenance does not increase if the company does not aim for level 3 maturity. They also have the possibility to develop that dimension in nine months, so it is a reasonable target.

To develop this dimension, they mentioned that they need strong cooperation with different organizational units to create ways to collect, store and analyze data from maintenance. The company must also create a process for recognizing their current and upcoming products in their information systems. With that, they could be able to track all maintenance actions done to one specific product and that way develop their fleet management as a whole. The participants thought that this level is highly related to the technology dimension, and that they should develop these levels simultaneously in order to proceed further.

Technology

The short-term target maturity level of technology dimension was also set to level 3. The group A participants in the workshop thought that maintenance-related technology is a requirement for everything else. This is strongly linked to the data and analytics dimension because of ways of collecting, storing and handling data. It is not seen possible to attach sensors or other information collecting devices to already sold products, but the company's desire is to do that to upcoming products in the future.

To improve the maturity of technology dimension, the target organization needs collaboration with IT and other organizational units to understand the requirements and develop current information systems to fit the maintenance process. They also need to acquire the new information system, field service management system, to be able to bring the maintenance process from manual working to more automatic system. Other matter that stood out was that the company needs ways of bringing more information from their current ERP system to other information systems, so that the existing data could be combined with the data collected from the maintenance visits and the single product could be recognized in the different systems.

Organizational culture

The target maturity level for organizational culture was set as well to level 3. The participants stated that once the company really starts to develop maintenance business, the whole organization must be communicated that something is happening, and the company is focusing on creating new business. They must be able to speak out about unfinished things as well to create even more open environment and build trust among all employees.

Currently information about maintenance and its processes is shared among small group of people, but that information needs to be brought in front of the whole organization and all employees must understand the need for the maintenance business. The whole organization must be informed about future plans and goals, and information should be shared actively after the initial start of the maintenance development project.

Organization and processes

In organization and processes dimension, the short-term target maturity level was set to level 3. According to the workshop participants, processes and strong relationships between other stakeholders are needed to provide maintenance in the first place. The company wants to pilot and test different solutions for maintenance to develop it further.

To be able to improve the maturity of processes, the company needs to build a properly working network with partners and other stakeholders. After that, they must define the processes to create a base for the whole business. The company has to think how they want maintenance business to work in the future and who they want to include into that.

Skills and abilities

The short-term target maturity level for skills and abilities dimension was also set to level 3. It was discussed in the workshop that to be able to develop the maintenance processes and everything related to that, the company needs more recruitments and other resources. They do not currently have the possibility to develop maintenance, so this dimension should be their main focus before anything else. To do that, the company needs to identify the capabilities and needs, and share the responsibilities between the current organizational units.

The participants stated that the leap between maturity levels is quite big, but it is inevitable to take it to develop maintenance business at all. If the company does not have the resources and the right people in developing maintenance, they will not be able to go forward and to the next maturity levels with other dimensions. They also want to share

the responsibility of the maintenance business and its development, so that it really happens this time.

6.2.2 Long-term target state

The long-term target state of maintenance's maturity was also set in the workshop. The long-term in this case means three years, in which maintenance should be at the level shown in the figure 25.

	Data & Analytics	Technology	Organizational culture	Organization & Processes	Skills & Abilities
1					
2					
3					
4					
5					

Figure 25. *Long-term target maturity state*

As we can see from the figure above, targets are set to maturity levels 4 and 5 in each dimension. As the short-term maturity level targets were set on level 3, there are a lot to achieve in three years to get to these desired levels. Although, according to the professionals in group A, three years is a long time for a company that is constantly moving on and growing rapidly.

In the workshop, a discussion was held, where the participants were asked to tell reasons why the company wants to achieve a particular maturity level in long-term. These results are presented by dimensions below.

Data and analytics

The long-term target maturity level for data and analytics dimension was set to level 5. The company is planning to collect data straight from the products with technological solutions, which obviously requires that the ways of storing and making the data useful are clear and in order. The upcoming data warehouse should be integrated to this process so that this collected data could be used in reporting and analyzing maintenance business. If the data collected is at high level in quality's perspective, that enables the company to provide maintenance services and create business.

The participants stated that if the data and analytics dimension is at high maturity level, it enables other dimensions to progress to high levels as well. Once the company is capable of collecting data straight from their products, the data can be combined with other data and use it to support decision-making. To make the maturity of data and analytics to rise to level 5, the company needs to improve the technology dimension a lot as well. Information systems and processes should be clear before this dimension can develop further, but the company's goal is to be predictive in three years.

Technology

In technology dimension, the long-term target maturity level was set to level 4. The participants discussed that old, already sold products, will probably not have electronical devices to gather information ever. That's why the maturity level 5 will most likely never be achieved. However, for the new and upcoming products they are planning to attach technological inventions to make the whole maintenance business predictive.

They also stated that their information systems are surely capable to manage maintenance business after three years, and all the necessary procurements have already been done by that time. If the company is able to develop technology dimension to level 3 in nine months, they truly believe level 4 is achievable in three years.

Organizational culture

The long-term target maturity level of organizational culture dimension was set to level 5. The group A participants in the workshop believed that maintenance will become an important part of the company's business and the desire to go towards that is big. The company trusts that appropriate maintenance business will bring competitive advantage especially with major end customers.

To be able to achieve this giant leap from level 2 to level 5 in three years, the company needs to actively promote the maintenance business to their customers and make the customers understand that the products need service periodically. They must create own maintenance culture to the furniture business and share information about it with customers and own employees as well.

Organization and processes

The long-term target maturity level of organization and processes dimension was set to level 4. The participants stated that in three years they are most likely to pilot maintenance business and its processes in multiple countries and in multiple different ways. However, they think that it is unlikely to have similar, working process and business everywhere around the globe, which is the reason they put their target to level 4.

The company probably has created a network with multiple stakeholders and partners in three years and are able to provide maintenance to their customers. They believe that the organization is ready, and the processes are defined, but the predictiveness is a question globally.

Skills and abilities

In skills and abilities dimension, the long-term target maturity level was set to level 5. In the workshop, it was discussed that this dimension is the most crucial part of succeeding in creating maintenance business. If this dimension is not at high maturity level, the development of other dimensions can be slow and even impossible. The lack of resources, which was discussed already earlier, is the bottleneck of whole maintenance business development.

In three years, the company believes that they have recruited a lot of people to the after sales organization, which is responsible for maintenance business. The participants discussed that creating culture and processes around maintenance is the key to success with the right amount of resources and know-how.

7. DISCUSSION

This chapter includes the discussion about the current and target maturity state of the target organization. The answers gotten from the interviews were analyzed and the results can be found here. The plan for future development is also introduced as a roadmap with different time periods.

7.1 Current state of the target organization

As previously mentioned, the current state of maintenance of the target organization was evaluated by the employees in the semi-structured interviews. The entirety of the current state of maintenance in the company can be seen in the figure 26. Group A's answers are colored in blue and group B's answers in red.

	Data & Analytics	Technology	Organizational culture	Organization & Processes	Skills & Abilities
1	A	A			
2	B	B	A	A	A
3			B	B	B
4					
5					

Figure 26. *Current maturity state of the target organization*

As we can see from the picture above, the answers are varying a lot between the two interview groups. Group B's answers are at every dimension one level above compared to group A's answers. Because group A consists of people working with the company's maintenance business closely, that result is kept as a ground base in this study, and future results will be compared to that.

In the interviews, the participants were asked about the biggest reasons why the situation is what it is currently. The most common answer to that question was that because the company has grown so fast and so much in a short time, they have not had the strategic focus on maintenance or in after sales at all. No one has taken responsibility of developing maintenance business although they have had some ideas before.

The biggest bottlenecks in the maturity model and in the maintenance can currently be seen to be in the data and technology dimensions. Both of these dimensions were evaluated by the group A to be at level 1 in the maturity model, which indicates that there has not been any development regarding data and technologies linked to maintenance. The biggest issue that was brought up by multiple interviewees was in recognizing the single products in their current information systems. That requires master data development and integration between different information systems.

The aim for the recognition of one single product is to be able to provide maintenance based on data. If the product cannot be recognized in any information systems, it is impossible to provide targeted maintenance services to customers. That is the most important matter in the whole development process, as the target is to be able to know the failures in a certain product before any breakdown happens, and to offer maintenance services for these specific customers.

Because the master data is not competitive at the moment, all the other aspects of data are lacking as well. Maintenance data does not have an owner, which makes it currently impossible to even start any development projects regarding the data. The quality of the data is also lacking, since there are not a lot of data collected in the first place. That is also a very important issue in this field, as the organization needs to find out possible solutions for collecting data from the products, in order to provide predictive maintenance.

All these issues lead to the last subdimension of data dimension that was presented in the maturity model, reporting and visualization. Since there are no data collected neither from the products nor from the maintenance visits that have been executed thus far, there is no possibility to use that data in decision-making. The target organization has a lot to do with this subject in order to develop the maintenance business they are achieving for.

The technology dimension is linked to the data and analytics dimension because the information systems enable the acquisition and handling of data, as well as the data transfer between different systems. The current ERP and manufacturing information systems are at a good level according to the interviewees. The critical part here is to finish off the integration, so that the one specific product could be identified in the information systems.

Multiple interviewees pointed out the need for electronical service book or field service management system, which is crucial in predictive maintenance business. All maintenance orders and events for single product could be seen from there, which makes it a

necessary acquisition for the company. The company also must find the devices that can gather information about the conditions of the products and start integrating them into their new and already sold products.

The organizational culture dimension was evaluated to be at level 2 by the group A. The biggest issue here was in the mindset of their employees. The employees have not realized that their products need maintenance, which has slowed down the development and turned the focus to only selling the products. This must be changed within the organization with the help of open communication and information sharing between different organizational units. As the knowledge about maintenance currently lies within a small group of professionals, it will not go further without conscious sharing.

Another issue from the culture that was pointed out was the attitude of their customers and partners. As the furniture market is not known for maintenance, their customers and partners do not understand that the technological products the target organization is producing need maintenance in order to keep them working as they should. That mindset needs to be changed, and a new kind of culture must be created among their customers and competitors.

The organization and processes dimension was evaluated to be at level 2 as well by the group A. Here, the most common point that was brought up was in the lack of real processes regarding maintenance. The company have not been focusing on the development of maintenance business or maintenance visits overall, which has led to the current situation, where the maintenance is done case by case with no clear instructions or guidelines.

Multiple interviewees mentioned also the need for partners or other possible stakeholders in the maintenance business. As the target organization is working all over the world, they are not able to provide maintenance services by themselves. There the need for good relationships and contracts with partners is crucial. They also need to figure out the structure of their maintenance organization. Who is involved, and how the other resources should be utilized in the maintenance business, are important questions regarding to this subject.

Group A evaluated the skills and abilities dimension to be at level 2. The point that was brought up by almost every interviewee was that they are lacking resources to develop maintenance currently. There are skillful people within the current after sales organization, but they do not have the needed time for the development work. It was also pointed out that they need a lot more skills than the ones mentioned in the maturity model. These

missing skills included customer service skills and sales skills, which are needed to provide the world-class customer experience the company aims for and in order to sell the maintenance alongside their current products.

The issue that was brought up by multiple interviewees, and which is not considered in the maturity model, was the lack of business model for the maintenance business. Before anything else, the target organization should create a business model for how they want their maintenance to work in the future and what do they want to offer to their customers. Only by doing that, the development process for the whole maintenance subject can be started.

However, the company has now noticed the potential in maintenance business, and they have started to develop it. One of the interviewees stated that “Brand, quality and world-class customer experience will create competitive advantage in the future. We need to focus on these and with maintenance we are able to pursue those.” The company believes in the maintenance business, but they have a lot to improve to make it predictive and a part of the everyday business.

7.2 Target state of the target organization

The target state of maturity regarding maintenance was set in the workshop, which was held only for the professionals from the group A. In there, two target states were set for short-term and long-term time periods. The entirety of the two different target states decided in the workshop is presented in the figure 27. Short-term target state is colored in yellow, and long-term target state is colored in green.

	Data & Analytics	Technology	Organizational culture	Organization & Processes	Skills & Abilities
1					
2					
3					
4					
5					

Figure 27. *Combined target maturity state of the target organization*

As we can see from the figure 27, the targets were set to quite high levels in both of these time periods. As the short-term target state should be achieved only in nine months, there are a lot to develop in that time. The target levels set for the longer time

period are however quite moderate, if the short-term targets are achieved entirely. These short-term targets are discussed more thoroughly next, as the long-term target is the ultimate target for the organization and is not as realistic as the shorter.

The bottlenecks that were identified in the previous chapter were in the data & analytics and technology dimensions. In order to develop these dimensions from maturity level 1 to maturity level 3, a lot needs to be done. The participants in the workshop came to a conclusion, where the most important task is to focus on the identification process for a single product. That involves matters from both of these dimensions, as the master data should be fixed, and the needed information systems should be integrated with each other in a way it enables these operations. They also need to acquire the new information system in order to handle the maintenance orders digitally.

The development of organizational culture should start from open communication within the company. As the target is set to level 3, which is one level higher than the starting point, it is achievable by right ways of communicating. After their own personnel are aware of the situation and the need for this development regarding maintenance processes, it can be communicated to their customers as well. The creation of maintenance culture inside furniture business is a huge task, but it can be achieved in the long run.

The dimension of organization and processes was also set to level 3 as a short-term target. The company needs a clear process for executing maintenance operations before the maturity can develop in this dimension. They need to start creating a network with their partners and other possible stakeholders in order to achieve the desired targets. It was pointed out in the workshop, that the whole maintenance business should be developed in cooperation with their key customers, which means that the company must pilot different possibilities in different markets and environments.

The skills and abilities dimension was also set to level 3, which means that the company must find more skillful people to their current organization. The lack of resources is vast, and in order to develop the maintenance to a part of the business, they need more recruitments. That requires planning and identification of needs, which must be done before any recruitments.

The short-term targets were set to level 3 in each dimension. That is a quite high level, which means that the company has a lot to do in a short time. As the maturity of maintenance is currently very low and they do not have any kind of maintenance business to offer to their customers, they need to start from the scratch. How it can be done, is presented in the next subchapter, where a roadmap for the development process is introduced.

7.3 Roadmap for future development

Based on the interviews and workshop, a roadmap for future development was conducted. The visualization of the roadmap can be found from the appendix A. The roadmap for the next three years is divided into five different time periods, which consists of two quarters of a year, except for the last period. These periods and the recommendations for maintenance business development are presented next.

7.3.1 First period

The two dimensions that where evaluated to be at the worst situation were data and technology dimensions. The company should start from defining the process for master data, which in this case means identifying a single product in their information systems. They should be able to know exactly the model, design, customer and location of a single product in order to start developing the predictive maintenance processes. They also should set a responsible person for data management, in order to have some kind of systematics in the data concerning maintenance. From the technological point, the company should start integration between current manufacturing and ERP systems, in order to handle the single product inside information systems. The need for field service management system was also pointed out multiple times in the interviews, so they need to start searching for the right system for their use.

As the one of the biggest issues identified was in the skills and abilities dimension, the development of this should start simultaneously with the data and technology dimensions. The identification of needs of the company is the first matter that should be done. The company does not currently have enough resources to develop maintenance, so the process for planning the recruitments should start with the need identification.

From organization and processes dimension, the lack of reasonable processes is slowing them down. They should describe the desired processes and start the development work there. For this, the company needs a business model for predictive maintenance, which should also be created at the beginning of whole development process. It was also identified that the concept for maintenance organization, which is highly linked to the processes, should be created. From a cultural point of view, the company should start communicating internally about the development project of maintenance, in order to raise awareness for the need of this development work.

In this first period, the base for the whole maintenance development is created. To be able to continue from here, all the dimensions should be taken into account and the development work should start.

7.3.2 Second period

The second period of the maintenance development starts six months after the initial start of the process. In that time, the identification of the needs should have been done, and the recruitments for new employees should have started. That process will probably take a lot of time, which means that it must be started in good time.

Data processes should have also been started, and the next objective, data collection process should be under development. The ways of collecting data from the products are crucial in order to provide predictive maintenance, hence it should be developed as soon as the master data processes have been developed. This means also that the data collected must be stored somewhere, and the development work for data repository for maintenance data should start. Information system for handling the maintenance needs should have been acquired and the development work for platform for partner usage should start now. This platform is intended for partners that are ordering maintenance to their products. In order to collect data, the products also need technological devices, and these should be now integrated to the new products.

When the communication about maintenance for the internal organization has started, this should be expanded for the customers as well. Since the furniture market is not known for maintenance, the company must start creating culture for that among their customers and competitors. The processes for maintenance should have been developed to some extent, which means that the company can start creating the organization around the maintenance. This means establishing networks between different stakeholders and partners and training them to be a part of this ensemble.

After all this has been done, the maintenance business can be piloted in a small environment with, for example, few key customers. At this point, the maturity of all dimensions should have increased to maturity level 3.

7.3.3 Third period

The third period of the maintenance development process starts one year after the initial start of the whole process. The first pilot phase should be ongoing at the time, and work with recruitments should end here. This leaves time for the development of current employees' skills, which will eventually hasten the whole development process.

As the processes for data collection and storing should be done by now, the collected data can be used in reporting. That requires data cleaning, and the processes for that and reporting should be now created. Information acquisition devices for the new products should be implemented as well as the digital platform for partner usage.

The creation of the maintenance organization is still ongoing with the network creation with partners and other stakeholders. The culture creation among customers and competitors is still in progress as well. As the target organization is the first on the market to try developing maintenance business, a competitor analysis is a natural step in the development process.

After this third period, the company should have a solid ground for predictive maintenance business.

7.3.4 Fourth period

The fourth period starts half a year later after the start of the previous period, which means already one and a half years after the initial start of the whole development process. At this point, the main processes for predictive maintenance should have been developed. This means that the concept can be widened for larger usage, and the second pilot phase can start.

Also, the identification process of old products should start here. As the new products already have information acquisition devices by now, the old products need them as well. This is linked to the identification service, which is a new process in this entirety. The company can start offering identification as a service to its customers, in order to gain information about the old products, and at the same time integrate the information acquisition devices to them. After the fourth period, the predictive maintenance business should be almost complete.

7.3.5 Fifth period

The fifth period of the development process of predictive maintenance business starts two years after the initial start. At this point, the maturity of all the dimensions should have arisen from the lower levels reaching almost the maximum levels, and the capabilities of the target organization should have increased massively.

The company is now able to fully launch the predictive maintenance business and offer maintenance based on the data collected from their products. The maturity in dimensions data and analytics, organizational culture as well as skills and abilities should have reached the maturity level 5. This means that those dimensions cannot develop any further. The maturity of technology and organization & processes dimensions should be at level 4, which leaves space for further development in the future. This happens a little bit over two years after the initial start of the development process.

8. CONCLUSIONS

This is the final chapter in this study, and it includes the conclusions for the whole research process. There are answers to the research questions that were set at the start of the research, as well as the evaluation of this study. Lastly, there are recommendations for future research concerning the subject.

8.1 Research questions

The main research question of this study was *How to establish predictive maintenance business in a furniture manufacturing company with the help of maturity models?* This main research question was divided into seven minor research questions, which were used to clarify the problem. The answer to the main research question is gotten from the combination of the answers to the minor research questions, which are presented next.

How maintenance is usually done in manufacturing companies?

Based on the literature research done for this study, there are multiple possible ways of executing maintenance in manufacturing companies. Maintenance is a part of the after sales services, which are commonly offered by different companies nowadays. These services currently provide a large amount of the whole revenue in manufacturing companies, as the products need a variety of maintenance operations to be done in order to keep them working as they should at all times. There are different types and strategies for organizing the maintenance business, and the selection of those depend on the occasion and the company providing maintenance.

What is predictive maintenance?

Predictive maintenance is a one strategy for organizing maintenance. There are different types of maintenance, proactive and reactive maintenance, and predictive maintenance is one strategy of proactive maintenance. Predictive maintenance means that the maintenance operations are organized in a way that is possible to predict upcoming failures or breakdowns in products or equipment. The idea is that these can be fixed or repaired before anything happens. Predictive maintenance uses data and information collected straight from the products, which makes it a data-driven approach for organizing maintenance. With predictive maintenance strategy one is able to achieve a high reliability of products and equipment, as well as decrease the possibility for major failures in, for example, production lines.

What are maturity models?

Maturity model is a concept for different development processes. Maturity models usually consist of different dimensions, maturity levels and attributes. The dimensions are subjects that are strongly affecting the development of the measured matter, and maturity levels are cumulative stages that are used to evaluate the situation regarding the researched subject. As the maturity levels develop, the capabilities of an organization or other party that is using the maturity model develop as well. Once the capabilities are developed, the maturity of the whole subject is increasing, and the organization is able to perform better regarding the subject.

How maturity models can help to define the level of maintenance in an organization?

Maturity models include different dimensions, which basically are topics that are critical in order to develop a certain process or entirety. They also include different maturity levels, which represent the maturity of these certain dimensions. The dimensions that are affecting maintenance in an organization were decided with the target organization and using the help of different already developed maturity models (Nemeth et al., 2018; Oliveira & Lopes, 2019). The current maturity levels of the target organization were evaluated in the interviews with the target organization's employees. These evaluated levels indicate the level of maintenance in an organization, as the maturity levels are linked to different stages of maintenance maturity.

What is the current state of maintenance in the target organization?

The current maturity state of maintenance was researched with the help of a customized maturity model. The maturity model was created for the target organization's needs concerning their development in maintenance. business. The maturity model was then used in the interviews, where 15 professionals from different organizational units had a chance to evaluate the current situation. They also had the opportunity to argue the reasons behind those results, which has led to the current situation. The result was that in data and analytics, as well as in technology, the target organization is at a very poor level. Organizational culture, maintenance processes and the needed skills are also at a low level, but a little bit better than the two firstly mentioned dimensions. The conclusion of this is that the company has a lot to do in order to be able to start providing predictive maintenance to their customers. They have to develop their capabilities in multiple different subjects and start the work as soon as possible.

What is the target state of maintenance in the target organization?

The target maturity state of maintenance in the target organization was decided in a workshop. There, two different target states were decided, a short-term target state, which is nine months, and a long-term target state, which is three years. The decision for setting two target states was justified by the organization with an explanation about their desire to develop fast and see further. Because they are just starting to develop the maintenance business, they want to set realistic objectives for short time period, but they also want to set ambitious objectives for the ultimate condition in the future. The short-term target state was set to maturity level 3 in each dimension. Long-term target states were varying between levels 4 and 5 in all of the dimensions.

How the organization will achieve the target state?

Based on the interviews and workshop that were conducted for this study, a roadmap for future development was created. That roadmap consists of all needed steps to develop the target organizations capabilities in maintenance. The roadmap was divided into five different time periods, which are supposed to be executed one after another. These periods include the dimensions from the customized maturity model and all the issues that must be developed in order to establish a predictive maintenance business within the target organization.

8.2 Research evaluation

The main objective of this research was to find out how predictive maintenance business could be established in a furniture manufacturing company. That required research about the possibilities to organize maintenance business in a manufacturing company, as well as a method for analyzing the situation at the furniture manufacturing organization. The method that was used was maturity model, which was customized and created to fit the target organization's needs. As all the research questions were answered, this study can be seen to be successful.

The current maturity state and the target maturity state of the target organization were evaluated and set, which indicates that the maturity model worked as it was planned. A roadmap for the development process for the company was created and it can be used in establishing the maintenance business.

In the literature research, case examples from different maintenance strategies could have been examined in more depth, in order to create a more concrete general view about the subject. Also, maturity models developed merely for maintenance development could have been investigated more. However, the literature research in this study

creates a big picture of different maintenance types and strategies, and clarifies the basics of maturity models, which are all needed in order to develop predictive maintenance for a manufacturing company.

The interviews that were conducted for this study in order to get information about the target organization could have been more consistent throughout all the interviews. There were few points that came out in the first interviews, which were then corrected to the latter interviews. That made the results from the first interviews a little bit uneven, as all the questions were not asked there. Nevertheless, the interviews were supposed to be semi-structured, which makes it possible to change the way of conducting them each time.

The usage of maturity model in evaluating the current situation of the target organization was seen as a very useful approach by the case company and by the researcher. The feedback gotten from different participants in the interviews, workshop and other discussions was highly positive, which indicates that maturity models were the right choice for approaching the problem in maintenance business development. Maturity model thinking in general and the customized maturity model adduced matters that were not thought by the target organization earlier and presented new aspects for the subject. It also clarified that the target organization has a lot to develop before they can start offering maintenance services to their customers, which means that the needed time is probably more than they expected.

All in all, it can be said that this study was successful in answering the research questions and solving the research problem. This study can be used in the development process of maintenance business in the target organization, and it could be used as a base for future researches on the same topic.

8.3 Research topics for the future

There are few possible research topics for the future that could expand the subject of this study further. One topic for the future research could be the evaluation of the possible benefits this study has accomplished. The research could examine the possible positive and negative effects this study has made in the target organization or the implementation process of the created roadmap.

This study could also be widened to another field, which is not furniture business. There has been already a lot of maturity model development in other fields, but not so much from maintenance's point of view. Establishing predictive maintenance business to another market could be an interesting research topic.

Also, a research on already established maintenance business could be interesting. Using maturity models to evaluate the situation in an environment, where maintenance is a part of an organization’s basic operations, the possibilities to develop, for example, prescriptive maintenance could be useful.

REFERENCES

Ali-Marttila, M. (2015). Tunnista, mitä verkostokumppanisi arvostavat kunnossapitopalvelussa. Verkostomainen kunnossapito – kolmiodraama vai teollisuuden Dream Team?. KP-Media Oy. pp. 13-25.

Alston, J. M. (2019). What's the difference between a conference, a seminar, a workshop and a symposium?. Conference Monkey. Available online: <https://conferencemonkey.org/insight/whats-the-difference-between-a-conference-a-seminar-a-workshop-and-a-symposium-1075915>. Retrieved: 26.02.2020.

Beck, R. (2019). A Vision for the Refinery of 2030. Hydrocarbon Processing. May 2019.

Becker, J., Knackstedt, R. & Pöppelbuß, J. (2009). Developing Maturity Models for IT Management. Business & Information Systems Engineering, Vol. 1 (3), pp. 213–222.

Bigdeli, B. & Safi, S. (2005). Proactive Versus Reactive Maintenance Measurement/Improvement. ICOMS-2005, 42.

Borchardt, M., Souza, M., Pereira, G. M. & Viegas, C. V. (2017). Achieving better revenue and customers' satisfaction with after-sales services – How the best branded car dealerships get it? International Journal of Quality & Reliability Management. Vol. 35 No. 9, 2018.

Chan, R. & Young, C. (2019a). How maintenance will revolutionize the world. UpKeep. pp. 12-31.

Chan, R. & Young, C. (2019b). Emergency Maintenance. UpKeep. Available online: <https://www.onupkeep.com/learning/maintenance-types/emergency-maintenance>. Retrieved: 15.01.2020.

Chen, J. (2018) After-Sales Support. Investopedia. Available online: <https://www.investopedia.com/terms/a/aftersales-support.asp>. Retrieved: 13.01.2020.

Curry, D. S. (2018). Interpretivism and norms. Springer Nature.

de Bruin, T., Kulkarni, U., Freeze, R. & Rosemann, M. (2005). Understanding the Main Phases of Developing a Maturity Assessment Model.

Deighton, M. G. (2016). Facility Integrity Management. Chapter 5 - Maintenance Management. Gulf Professional Publishing. pp. 87-139.

Devine, M. (2018). After-sales service is the key profit – lever for 2018. Manufacturing Management. Available online: <http://manufacturingmanagement.co.uk/features/after-sales-service-is-the-key-profit-lever-for-2018>. Retrieved: 13.01.2020

Elphick, R. & Jameson, P. (2011) Maintenance types. ICE Manual of Highway Design and Management. Institution of Civil Engineers. pp. 579-584.

Exner, K., Schnürmacher, C., Adolphy, S. & Stark, R. (2017). Proactive maintenance as success factor for use-oriented Product-Service Systems. Procedia. CIRP 64 (2017). pp. 330 – 335.

Farquhar, J. D. (2012). Case Study Research for Business. London, SAGE Publications Ltd.

Fedele, L. (2011). Methodologies and Techniques for Advanced Maintenance. Springer London. pp. 44-45.

Fowler, M. (2014). Maturity Models. Available online: <https://martinfowler.com/bliki/MaturityModel.html>. Retrieved: 05.02.2020.

Fraser, P., Moultrie, J. & Gregory, M. (2002). The use of maturity models / grids as a tool in assessing product development capability: a review. IEEE International Engineering Management Conference. Vol 1. pp. 244 – 249.

Frick, N., Küttner, T. F. & Schubert, P. (2013). Assessment Methodology for a Maturity Model for Interorganizational Systems – The Search for an Assessment Procedure. IEEE Computer Society.

Galar, D. & Kumar, U. (2017). eMaintenance. Chapter 6 – Prognosis. Academic Press. pp. 311-370.

Gebauer, H., Friedli, T. & Fleisch, E. (2006). Success factors for achieving high service revenues in manufacturing companies. Benchmarking: An International Journal. Vol. 13, No. 3, 2006. Emerald Group Publishing Limited.

Gilchrist, A. (2016). Industry 4.0: The Industrial Internet of Things. Chapter 1: Introduction to the Industrial Internet. Apress.

Hupjé, E. (2018). 9 Types of Maintenance. Road to Reliability.

Jardine, A. K. S., Lin, D. & Banjevic, D. (2006). A review on machinery diagnostics and prognostics implementing condition-based maintenance. Mechanical Systems and Signal Processing. Vol. 20, Issue 7. October 2006, pp. 1483-1510.

Keap. (2019). After Sales Service – Create loyalty and fresh leads with the right customer aftercare. Available online: <https://keap.com/product/after-sales-service>. Retrieved: 13.01.2020.

Kohlegger, M., Maier, R. & Thalmann, S. (2009). Understanding Maturity Models - Results of a Structured Content Analysis. Proceedings of I-KNOW ’09 and I-SEMANTICS ’09. pp. 51-61.

Koons-Stapf, A. (2015). Condition Based Maintenance: Theory, Methodology & Application.

Krar, S. (2015). The Importance of Maintenance (Changing from a FAIL and FIX Approach to a PREDICT and PREVENT Approach). Available online: <http://www.automationmag.com/images/stories/LWTech-files/94%20Intelligent%20Systems.pdf>. Retrieved: 15.01.2020.

Levitt, T. (1983). After the Sale Is Over… . Harvard Business Review. September-October. pp. 87-93.

Marr, B. (2018). What is Industry 4.0? Here's A Super Easy Explanation For Anyone. Forbes. Available online: <https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#3b58c0579788>. Retrieved: 16.01.2020.

Mehta, B. R. & Reddy, Y. J. (2015). Industrial Process Automation Systems. Chapter 18 – System Maintenance. Butterworth-Heinemann. pp. 523-545.

Morgan, J. (2014). A Simple Explanation of ‘The Internet of Things’. Forbes. Available online: <https://www.forbes.com/sites/jacobmorgan/2014/05/13/simple-explanation-internet-things-that-anyone-can-understand/#1b0e31301d09>. Retrieved: 16.01.2020.

MSG. (2019). After Sales Service / Customer Service. Management Study Guide. Available online: <https://www.managementstudyguide.com/after-sales-service.htm>. Retrieved: 13.01.2020.

Nemeth, T., Ansari, F., Sinh, W., Haslhofer, B. & Schindler, A. (2018). PriMa-X: A reference model for realizing prescriptive maintenance and assessing its maturity enhanced by machine learning. Procedia CIRP 72 (2018). pp. 1039–1044.

Nguyen, H. (2018). What is predictive maintenance (PdM)? Its Pros and Cons. TRG International. Available online: <https://blog.trginternational.com/introduction-to-predictive-maintenance-techniques>. Retrieved: 15.01.2020.

Oliveira, M. A. & Lopes, I. (2019). Evaluation and improvement of maintenance management performance using a maturity model. International Journal of Productivity and Performance Management. Emerald Publishing Limited. 1741-0401.

Penny, J. (2019). Prescriptive Maintenance: The Next Generation Solution. Buildings – Smarter Faculty Management. Available online: <https://www.buildings.com/news/industry-news/articleid/21974/title/prescriptive-maintenance-next-generation>. Retrieved: 15.01.2020.

Ranade, V. (2019) Data-driven maintenance – simplified. Medium. Available online: <https://medium.com/@ranaday/data-driven-maintenance-simplified-107192a6ba61>. Retrieved: 15.01.2020.

Saunders, M. N. K., Lewis, P. & Thornhill, A. (2009). Research Methods for Business Students. 5th edition. Pearson Education Limited. pp. 107-109, 115-116, 124-127, 141-150, 318-321, 480-482, 485-495.

Segzdaite, E. (2018). Advantages and Disadvantages of Reactive Maintenance. Dynaway. Available online: <https://www.dynaway.com/blog/reactive-maintenance>. Retrieved: 15.01.2020.

Soni, A. (2019). Predictive Maintenance vs. Preventative Maintenance. Hitachi Solutions. Available online: <http://us.hitachi-solutions.com/blog/predictive-maintenance-vs-preventative-maintenance/>. Retrieved: 15.01.2020.

Straehle, O., Roth, P. & Herr, C. (2015). Winning in an industrial service: The hallmarks of a service champion. Bain & Company.

Tuomi, J. & Saarijärvi, A. (2018) Laadullinen tutkimus ja sisällönanalyysi. 2nd edition. Tammi Publishers.

Van Looy, A., De Backer, M., Poels, G. & Snoeck, M. (2013). Choosing the right business process maturity model. Information & Management. Vol. 50 (2013). pp. 466-488.

Vavra, B. (2017) The next frontier: Prescriptive maintenance. Plant Engineering. May 2017. Vol. 71 (4). p. 25.

Weber, C., Königsberger, J., Kassner, L. & Mitschang, B. (2017). M2DDM – A Maturity Model for Data-Driven Manufacturing. Procedia CIRP 63 (2017). pp. 173 – 178.

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. Information and Software Technology. 54 (2012). pp. 1317-1339.

Westerkamp, T. A. (2013). Maintenance Manager's Standard Manual (5th Edition) - 9.3 How to Plan for Emergencies. BNI Building News. pp. 97-99.

Wilson, T. L. (1999). International After-Sales Services. Journal of Global Marketing. 13:1, pp. 5-27.

Zhao, J. & Yang, L. (2017) A bi-objective model for vessel emergency maintenance under a condition-based maintenance strategy. SIMULATION 94 (7). pp. 609–624.

APPENDIX A: ROADMAP FOR MAINTENANCE DEVELOPMENT