



**CHALMERS**  
UNIVERSITY OF TECHNOLOGY

# **Critical Success Factors When Implementing Failure Mode and Effects Analysis (FMEA)**

A Case Study of Process-FMEA at a Global Automotive Manufacturing Company

Master's thesis in the Master Degree Program Quality and Operations Management

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**Division of Service Management and Logistics**

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## Abstract

This thesis concerns the implementation of Failure Mode and Effects Analysis (FMEA). There are many different quality tools and practices used today and the implementation greatly impacts the success of the tool. Moreover, FMEA is a common tool but there is limited research on how to best implement it. The purpose of this research was therefore to understand what critical success factors there are when implementing a global FMEA standard. The purpose was fulfilled by firstly studying the literature on FMEA usage and implementation of quality tools and practices. The literary findings resulted in a framework of Critical Success Factors for implementing FMEA. A number of success factors were identified within the following areas:

- Leadership
- Organizational
- Knowledge
- Individual
- Processual
- Stakeholder Management
- Contextual
- Effective FMEA Practice

Secondly, empirical research was performed at a case company that uses Process Failure Mode and Effects Analysis (P-FMEA) and were aiming to implement a new, global P-FMEA according to a handbook on FMEA by Automotive Industry Action Group (AIAG) and Verband der Automobilindustrie (VDA). The empirical findings were analyzed based on the theoretical framework. Lastly, the findings from the analysis were used to create recommendations for the implementation of P-FMEA and representatives from the case company participated in a workshop to prioritize the recommendations based on feasibility and impact. Some of the recommendations were considered quick-wins, such as establishing senior management support at all sites, while others were major projects, for example to implement a training initiative.

Keywords: FMEA, P-FMEA, CSF, Implementation, Quality tools, AIAG-VDA, Automotive.



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David Gisslén & Helena Gästrin, Gothenburg, May 2021



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# Acronyms

<b>AIAG</b>	Automotive Industry Action Group
<b>BP</b>	Best Practice
<b>BPI</b>	Best Practice Interventions
<b>CSF</b>	Critical Success Factors
<b>D</b>	Detection
<b>D-FMEA</b>	Design Failure Mode and Effects Analysis
<b>FC</b>	Failure Cause
<b>FE</b>	Failure Effect
<b>FM</b>	Failure Mode
<b>FMEA</b>	Failure Mode and Effects Analysis
<b>JIT</b>	Just-in-time
<b>KPI</b>	Key Performance Indicator
<b>O</b>	Occurrence
<b>OEM</b>	Original Equipment Manufacturers
<b>P-FMEA</b>	Process Failure Mode and Effects Analysis
<b>PIP</b>	Process Improvements Programs
<b>QMS</b>	Quality Management System
<b>QS</b>	Quality System
<b>QT</b>	Quality Tools
<b>RPN</b>	Risk Priority Numbers
<b>S</b>	Severity
<b>SOD</b>	Severity Occurrence Detection
<b>TPM</b>	Total Productive Maintenance
<b>TQM</b>	Total Quality Management
<b>VDA</b>	Verband der Automobilindustrie



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# 1

## Executive Summary

This thesis has been conducted to establish critical success factors when implementing FMEAs. The study has resulted in a list of recommendations for the case company to take into consideration in their future implementation of a AIAG-VDA P-FMEA. These have evolved from months of literature research and data collection. The thesis started with an extensive literature phase where success factors regarding both FMEAs and implementing quality tools and practices were established. The factors from each area were analyzed and categorized, and this lead to the formulation of a new framework. The framework can be used by companies to analyze their current activities in order to find out what they should focus on when wanting to implement FMEAs. The framework also acted as a base for the next phase, the interview phase. Several members of the case company who were involved or connected to the company's P-FMEA work were interviewed regarding topics related to the success factors found in the literature phase. The findings from the interviews were then compared to what the literature say about the same things. The findings from the interviews together with other sources such as observations and company documents were used to diagnose the case company's current P-FMEA. As previously mentioned, this resulted in a list of recommendations that the researchers believe the case company would benefit to implementing. These were presented in a prioritization workshop to a small group of individuals from different departments and locations in order to get the site and functional differences incorporated in the decisions. The aim of the workshop was to let the participants value the list of recommendations in two aspects, feasibility and impact. Feasibility is how easy the recommendation is to implement, impact is how great the impact is on the organization. The results from the workshop can be studied in detail in Figure 7.2. The list of recommendation is displayed in the next section.

### 1.1 Recommended actions

Based on what has been identified in the literature, empirical findings and the result from the prioritization workshop a list of recommended actions has been assembled, seen in Figure 1.1.

1. Senior management support at all sites
2. Define purpose
3. Define time policies
4. Define team policies
5. FMEA-report
6. Define how P-FMEA should be prioritized or not be de-prioritized
7. Establish the connection to other tools and functions
8. Implement a facilitating role in their future P-FMEA meetings
9. Standardize where to save
10. Establish change champions on all sites
11. Implement a training initiative
12. Standardize the description of failures
13. Define updating P-FMEA policies
14. Establish a process to evaluate the P-FMEA
15. Make use of lessons learned
16. Make adaptations to fit the capabilities of the different sites

**Figure 1.1:** Priority order for the recommendations. Green represents quick wins (1-4, 6, 9-10, 12), blue major projects (7-8, 11, 13-15), and yellow fill-ins (5, 16).

The recommendations are a mix of mostly quick wins and major projects. The order of the actions is based mostly on the prioritization workshop, but some factors have been given a higher priority based on strong agreement in the literature on their importance. These are the FMEA-report and to implement a training initiative. The FMEA-report was in the workshop misinterpreted and perceived as a major “doctorial report” and therefore seen as only a paperwork exercise. The report is instead supposed to be an easy document to inform senior management and other stakeholders of key points from the P-FMEA, such as what the major risks are, how they have been dealt with and what issues are left in the product. These findings should be summarized in a “one-pager”, without extensive detail since that would transform it from a valuable tool that lets senior management be involved in P-FMEA to a paperwork exercise that benefits neither the writer nor the reader.

The other recommendation that has been given higher priority than what was stated in the workshop is to implement a training initiative. It is true that a great facilitator in the P-FMEA team will lessen the need for the other participants to be experts but that does not mean that they should be completely without training. It was highlighted in the interviews that the participants of a P-FMEA meeting needs to have a holistic understanding of the methodology as well as why the company perforce it. The motivation and attitude of the participants have also been emphasized in the interviews as impacting the success of a P-FMEA and a good way to establish how the company wants to view the meetings is trough joint training. This training does not necessarily have to be very formal - one interviewee brought up creating

information videos. The point is that the purpose, motivation and general methodology have to be clear to all those participating in P-FMEAs to enable success and this could be achieved by training.

## 1. Executive Summary

---

# 2

## Introduction

Many researchers have emphasized the importance of quality as a competitive advantage (Ferdows & De Meyer, 1990; Su, Linderman, Schroeder, & Van de Ven, 2014; Weckenmann, Akkasoglu, & Werner, 2015). However, quality of products have gone from being a differentiating factor to a market requirement (Lukas & Menon, 2004) and for example, Takeuchi and Nonaka (1986) stress that the success of new product development is not only dependent on high quality, low cost and differentiation, but also speed and flexibility. With the increased pressure for quality together with factors such as speed and flexibility, problem prevention rather than problem reaction becomes essential (Banduka, Veža, & Bilić, 2016; Carlson, 2012). There are a number of Quality System (QS) and practices to improve quality adopted by organizations today. From larger systems such as Total Quality Management (TQM) and Quality Management System (QMS) to Quality Tools (QT) such as House of Quality and Failure Mode and Effects Analysis (FMEA). In the automotive industry it is common for car manufacturers to demand their suppliers to fulfill certain quality standards and certifications (Aldridge et al., 1991; Johnson & Khan, 2003; Teng et al., 2006). Process Failure Mode and Effects Analysis (P-FMEA) is one common variant of the FMEA that falls into that category of a requirement for fulfilling certain quality standards such as ISO9000 and QS9000 (Johnson & Khan, 2003; Teng et al., 2006). In the P-FMEA, the aim is to identify faults that might occur from the product not being manufactured according to its specification, for example through machine variations or operators misassembling parts (Aldridge et al., 1991; Dale & Shaw, 1990).

In order to get a more coherent usage of FMEAs, automotive manufacturers have through joint forces created guidelines and handbooks to help their suppliers improve quality so that their end-consumer receives a more reliable product (Kluse, 2018). There are a variety of handbooks for different markets and countries created by different organizations. One example is Automotive Industry Action Group (AIAG) from USA and Verband der Automobilindustrie (VDA) from Germany who recently published a joint standard for automotive suppliers in both the markets (Kluse, 2020). The AIAG-VDA FMEA handbook sets a global standard on how to perform FMEAs, resulting in a step-by-step guide for all suppliers of the automotive industry, both in Europe and USA. It functions as a Best Practice (BP) for

suppliers to adapt into their operations. Browning and Heath (2009) claim that BPs are generic which make them transferable across contexts. However, in reality this is not always the fact, the benefits gained are instead often inconsistent (Hines, Holweg, & Rich, 2004; Jadhav, Mantha, & Rane, 2014; Staats, Brunner, & Upton, 2011) and companies sometimes fail completely when implementing QS like TQM (Binney, 1992; Harari, 1993). Researchers have emphasized that context and adaptation of implementations and practices are critical (Benson, Saraph, & Schroeder, 1991; Brunet & New, 2003; Collins & Browning, 2019; Done et al., 2011). It would therefore be of interest to investigate the implementation of a best practice and how contextualization affects it.

Moreover, implementing new practices can be based on an internal need but the AIAG-VDA handbook is something that automotive manufacturers might demand of their suppliers. As mentioned earlier, best practices are sometimes challenging to implement despite an internal need to change. What will happen when these practices are imposed on you by your customers? Johnson and Khan (2003) state that there is no guarantee of any value being gained by imposing practices such as FMEA on your suppliers. If the suppliers do not recognize the value of the tool, there is also a risk that the FMEA is only viewed as a paperwork exercise to please the customers (Aldridge et al., 1991; Dale & Shaw, 1990; Johnson & Khan, 2003).

Dale and Shaw (1990) have shown that one of the main reasons for suppliers to use FMEA is because their automotive customers demand it, and that a major obstacle is a lack of understanding why the FMEA is done. Aldridge et al. (1991) also point to the problem of doing an FMEA just because the customer says so and the importance of making all personal involved in FMEA understand its value. This indicates that there might be a gap between the value creating FMEAs described in theory (Dale & Shaw, 1990) and those FMEAs that are implemented in practice. It would therefore be of interest to identify what factors influence the success of implementation.

To facilitate implementation, it would be beneficial to establish Critical Success Factors (CSF). CSF are defined by Boynton and Zmud (1984) as *"those few things that must go well to ensure success for a manager or an organization"* (p. 17). Furthermore, some factors seem to play important roles when seeking success in performing Best Practice Interventions (BPI) (Done et al., 2011). A successful implementation is in this research defined as an implementation where the tool or practice is sustained over time. By developing recommendations for a more effective FMEA implementation, the tool could be better utilized and therefore bring more value to organizations. This could also potentially stop the tool from being viewed as just a check in the box to please customers. With this in mind, the purpose of this research is to understand what critical success factors there are when implementing a global FMEA standard.

## 2.1 Research Questions

Based on the purpose, it is of interest to identify critical success factors when implementing FMEA more generally, leading to the first research question being:

**RQ1. What critical success factors are there when implementing an FMEA?**

The other part of the purpose concerns the implementation of a global P-FMEA standard, such as the new AIAG-VDA handbook in a manufacturing setting. This leads to the second question:

**RQ2. What critical success factors are there when implementing a standardized P-FMEA according to the first edition AIAG-VDA standard in a global manufacturing company?**

## 2.2 Demarcations

Since the project is a master thesis, the time and scope are limited. This leads to a few implications. P-FMEA is the main focus even though the handbook includes Design Failure Mode and Effects Analysis (D-FMEA) and Supplemental Failure Mode and Effects Analysis. However, the findings of this thesis might still be useful to some extent when implementing other FMEAs. Moreover, implementing these kinds of tools takes more time than what the duration of the thesis permits. Thus, the conclusions will not include a full company-wide implementation and its long-term effects.



# 3

## Frame of Reference

This chapter will present a theoretical background of implementing FMEA. First, quality management will be briefly described to display the applicability of quality tools in general and FMEA specifically. Next, FMEA will be described in more detail and a number of factors will be presented that impact the success of FMEA. This is to get an understanding how the tool can be used most effectively. After that, success factors for implementing quality tools and practices will be introduced, to enable the identification of critical success factors when it comes to implementing FMEA. At the end of the chapter, a framework representing the literary view on success factors when implementing FMEA will be presented.

### 3.1 Quality Management

Weckenmann et al. (2015) have described the history and trends of Quality Management. The focus was first to inspect products and make sure that no known faults reached the customer, and to scrap the products that did not live up to standard. With an increasing economic and customer pressure, the view shifted toward focusing more on the process, where manufacturing processes were controlled to reduce the defects being produced, rather than scrapping the products when the damage was already done. From this, quality management evolved further to work with preventive measures and try to identify quality risks *before* they occur. When the need to also consider the quality of suppliers grew greater, the quality management began to be standardized through certifications such as ISO 9000. The quality practices have in turn evolved into TQM, where a holistic view is taken and improvement is driven by a constant wish to become better (Weckenmann et al., 2015). The standardization through certificates is still used today, and for example the automotive industry is driving the development of standards such as ISO/TS 16949 and IATF 16949 (Gruszka & Misztal, 2017). The aim for the standards were to create a global quality management system to cover the supply chain of the industry and setting rules and guidelines regarding design, development, and production for suppliers (Gruszka & Misztal, 2017). However, the standards also allow for specific customer requirements to be set, and these can include a number of different quality tools (Gruszka & Misztal, 2017).

To succeed with quality improvement, using different tools and techniques is central (Bunney & Dale, 1997), and it is also an important part to ensure compliance with requirements of standards and customer demands (Gruszka & Misztal, 2017). Throughout the history of Quality Management, a variety of tools have been used, when focus was on process control, tools such as Statistical Process Control (SPC) and Design of Experiment (DoE) were widely used. When the aim was to create quality through analyzing beforehand, FMEA became more central (Weckenmann et al., 2015). FMEA is often part of certification and customer requirements (Gruszka & Misztal, 2017; Teng et al., 2006) and organizations might therefore need to perform it to retain customers and certificates.

## 3.2 FMEA

FMEA is defined in the Reliability, availability, and maintainability dictionary as “*an engineering technique used to define, identify, and eliminate known and/or potential failures, problems, errors, and so on from the system, design, process, and/or service before they reach the customer*” (Omdahl, 1988). Benefits are gained by identifying the risks before they occur, by examining the ways a failure can occur. Preventive actions can be taken so that the product/service can be assured to have the highest reliability, quality and durability when it reaches the customers (Stamatis, 2013)

The tool was first introduced by the US Armed Forces in 1949, and has been applied by NASA and was actually used for the Apollo Missions (Ben-Daya, 2009). In the 1970s it was embraced by Ford (Carlson, 2012). Then it was adopted by the International Electrochemical Commission in 1985 and have since then been applied in numerous industries such as nuclear power industry, software, semi-conductor processing, web-based distributed design, and healthcare (Ben-Daya, 2009). It has also been adapted to different organizations and markets by making the tool a requirement in different quality standards such as IATF 16949, SAE’s ARP 4761 (Aerospace industry) and IEC 60812 (Electrical components) to name a few. In a survey among Swedish manufacturing companies, over 50 of 87 companies used P-FMEA and over 40 used D-FMEA (Arvidsson, Gremyr, & Johansson, 2003). Conclusively, it is a widespread and well-used tool applicable in many industries and organizations, and it has become a standard tool in many businesses today.

Stamatis (2013) describes the FMEA in different industries but also the process of conducting a generic FMEA. It is described in 8 steps:

1. *Select the team and brainstorm* — Select the cross-functional team that will do the analysis. The team tries to put up a plan on how to solve the problems - what type of issues can occur?
2. *Functional block diagram and/or process flowchart* — This step is to make sure that the team understands the product/product/system that the analysis is supposed to investigate.

3. *Prioritize* — When the team has understood the problem, they might have also realized that some parts of it are more important than others. A prioritizing order could be made so that the major problems are focused first.

4. *Data collection* — In order to understand the failures more, data is collected to help fill out the analysis.

5. *Analysis* — The analysis is conducted, filling out a form which consists of grading factors that in the end will give an estimate on how severe the risks are.

6. *Results* — The output from the analysis is quantitative, results from it is ranked and the team will put together a list of actions to prevent the severe failures to occur.

7. *Confirm/evaluate/measure* — After the actions have been taken, they need to be evaluated whether they have fixed the failures or not.

8. *Do it all over again* - Continual improvement is the focus, conduct the analysis again if necessary, the aim is to eliminate the failures.

While there are differences in FMEAs in different industries there are also different types of FMEAs. Mitigating risks is something that runs through an entire organization, from removing risk in the development of a new product to the production of it. Hence, the FMEA exist in different forms and it is generally accepted that there are four different types (Stamatis, 2013):

- **System-FMEA** - Used to understand the the system at a early stage in the development, the concept phase.
- **Design-FMEA** - Analyzes the design before it is released to the production, tries to mitigate failures in the product/service characteristics.
- **Process-FMEA** - Tries to find failures caused during the manufacturing process
- **Service-FMEA** - Analyzes failures of a service caused by system or process deficiencies

### 3.2.1 Compilation of literature on FMEA

This section will summarize some findings from literature regarding FMEA. Several themes have been identified and these are presented below.

#### Knowledge

Dale and Shaw (1990) examined the usage of FMEA in a number of UK motor companies. They summarized the main difficulties that the users encountered when trying to utilize the tool and one being “*Lack of Training*” (p. 187). Johnson and Khan (2003) investigated the use of P-FMEA in automotive suppliers and found that training varied a lot in duration and type. They also point out that issues might occur because of participants’ limited knowledge, for example of cause and effect. Lack of knowledge can also cause members of the FMEA-team to give vague and imprecise descriptions of risk factors (Liu, You, et al., 2019). Moreover, Teng et al. (2006) write that “*One of the keys for the successful implementation of FMEA is to ensure that all participants understand how to utilize FMEA.*” (p. 192).

Estorilio and Posso (2010) also point out the importance of training in their study of P-FMEA in the Brazilian automotive industry. They argue that the leader of an FMEA meeting should have experience of the tool and that the attendees should have training or at least be familiarized with it. Stamatis (2013) describes a facilitator that acts as an expert who can guide the team through the analysis, this person can also lead the FMEA team. Furthermore, Estorilio and Posso (2010) describe that the use of failure history mostly depends on people’s knowledge and that the use of a failure database could help feed information to future projects. Wirth et al. (1996) point to the issue of natural language in FMEAs making it difficult to reuse knowledge between different FMEAs. They propose a taxonomy system where descriptions are standardized and categorized based on technical concepts to mitigate this issue. Tumer et al. (2003) describe similar issues and propose a taxonomy system of potential failures with physical description of failures to facilitate knowledge-based decisions. In light of this, a common challenge of implementing and using FMEA seems to be education and knowledge, and many researchers emphasize the importance of it.

#### **Attitude**

Another difficulty described in Dale and Shaw’s (1990) study was “*lack of understanding of the purpose of FMEA*” (p. 187). They also found that the main reason for the participants to perform FMEA was because of requirements from their customers. Johnson and Khan (2003) also conclude that companies perform P-FMEA because it is required of them. Furthermore, Aldridge et al. (1991) maintain that organizations should not use the tool only for the sake of the customers; doing it as a paperwork exercise is almost as challenging as doing it in a correct manner but with limited benefits.

Teng and Ho (1996) write that

*“if a company’s main purpose of developing the FMEA report is to fulfil customers’ demand, then the benefits of performing FMEA will be reduced, and the cost for the FMEA process may not be compensated by the benefits of performing the analysis except that it satisfies customers’*

*demand to have the report.”* (p. 9)

This indicates that it is common to see FMEA as something that is done just to please the customer or because it is required, but that researchers opine that it is important to perform it in a way that gives the organization value.

### **Linkage and fitness to the rest of the organization**

Wirth et al. (1996) describe that FMEA is often used as a stand-alone technique, that is not connected properly to the design process or other quality tools used by an organization. Teng and Ho (1996) agree with this and insist that the FMEA needs to be utilized in the overall quality system and that this is generally problematic for companies. The link between D-FMEA and P-FMEA as well as between FMEA and the design of products should also be prioritized (Teng & Ho, 1996). Regarding the last point, Aldridge et al. (1991) say that companies should not *“start the FMEA process when the design has reached an almost fixed state, when changes will be that much harder to effect.”* (p. 55). This highlights the need for the FMEA to be integrated with the design process to allow for insights from the FMEA to impact the design.

### **Resources**

One of the major downsides with the FMEA as a tool is that it requires a lot of resources and having the required amount of resources becomes important for the implementation of the tool (Johnson & Khan, 2003). The FMEA is described to be laborious, to take a considerable amount of time, and to be expensive (Wirth et al., 1996). Teng and Ho (1996) describe this aspect:

*“The development of the FMEA report needs time, manpower, and a lot of effort. If all these resources are wrongly spent on a single purpose – just the development of the report – then the implementation of FMEA is very questionable.”*(p. 26)

So it seems like researchers agree that the FMEA is a tedious and resource-demanding work. However, in studies that list difficulties for companies in using the FMEA, this is not found to be one of the major issues (Dale & Shaw, 1990; Johnson & Khan, 2003). Nevertheless, the fact that it is not one of the biggest issues does not remove the fact that it is still a problem. To have the resources needed to perform the analysis correct is crucial for the implementation of the tool (Johnson & Khan, 2003).

Another aspect of FMEA is that it does not take costs or resources into consideration, there is no part in the tool evaluating this aspect. Johnson and Khan (2003) state two findings regarding this:

*“First, the PFMEAs’ progress was rarely measured against a programme and second, there is no universal technique being presently used by the suppliers for measuring any of the aspects of a PFMEA, such as cost, benefits, effectiveness and contribution to continuous improvement or reliability. ”*

Moreover, since using the tool identifies failures before they happen it becomes difficult to evaluate how much is saved since the cost of the consequences is unknown. This results in companies having trouble quantifying the cost and resource utilization (Johnson & Khan, 2003). As described earlier, there are articles describing the aspect of attitude, and that performing FMEA only because of customer demands could limit its benefits. The companies that perform FMEA only to satisfy their customers may not be compensated for its investment in performing the analysis other than making the customer happy (Teng & Ho, 1996).

#### **Practical usage**

While this thesis investigates the implementation of FMEAs, the practical difficulties in using the tool must be taken into consideration. Lets say, the tool is implemented in a successful way, how long does it sustain over time if it is considered to be difficult to use? Establishing and making sure that the usage of the tool is effective and simple could aid companies in sustaining the tool over time, hence facilitating the long term implementation. Effective is in this thesis defined as procedures that enables the usability of the tool and makes sure it creates value. When it comes to practical difficulties with the FMEA, many companies describe problems with for example setting the Severity Occurrence Detection (SOD)-ratings (Dale & Shaw, 1990; Johnson & Khan, 2003). Moreover, many articles point toward the problems with Risk Priority Numbers (RPN) (Liu, Wang, You, & Wu, 2019; Liu, You, et al., 2019; Segismundo & Miguel, 2008; Puente, Pino, Priore, & de la Fuente, 2002), and one of the problems with the system will also be demonstrated in Subsection 4.4.1.

There are other aspects of rating which are causing difficulties in the FMEA-process. Estorilio and Posso (2010) and Johnson and Khan (2003) point toward the subjectivity of evaluating the SOD-ratings. The examples given in text- and handbooks give room for interpretation. This is causing the team evaluating the failures to decide themselves what they feel would be the best. For example, two teams are evaluating the same failure, both end up in the same dilemma, it is either a 7 or an 8. One team decides to go with the 7 and the other decides to go with the 8. There is no system stating who is wrong or right here and that is why the rating usually is subjective and teams tend to use their own ad hoc-rules on how to take decisions. As mentioned earlier, team members may make vague and imprecise decisions regarding RPN due to lack of knowledge and information (Liu, You, et al., 2019). Guerrero and Bradley (2012) state that scoring should be executed as a group effort and not by letting one individual do it with the rest of the team reviewing it.

Teng and Ho (1996) also discuss the aspect of timing and emphasizes the importance of performing the analysis when there is the right time to do it, and not when its too late to make changes in the process, this aspect is also brought by Aldridge et al. (1991) who explain the difficulties of changing the process when it has reached a fixed state.

Tumer et al. (2003) points out that many FMEA ...*“had poor results due to poor reusability arising from the inconsistent descriptions of the functions of the components or systems and the failures they undergo.”* (p. 2). Wording also seems to be an aspect that has to be considered in order to facilitate the performance and implementation of the tool but it could also be used to enhance knowledge-integration as shown by both Tumer et al. (2003) and Wirth et al. (1996).

There are also processual aspects that needs to be considered for the optimization and performance of the tool. A few of those concern the team and many articles emphasizes the importance of teamwork (Dale & Shaw, 1990; Estorilio & Posso, 2010; Johnson & Khan, 2003; Teng et al., 2006). Group constellation is also discussed and it needs to be cross-functional (Aldridge et al., 1991; Stamatis, 2013), the functions needed will be described in Subsection 3.2.3. While it is important to have the right mix of people to facilitate the performance, it is crucial that the size of the team is restricted to as few as possible since this will otherwise cause difficulties in the decision-making process (Aldridge et al., 1991; Dale & Shaw, 1990). The meetings should not be longer than 90 minutes to ensure that team-members stay focused (Estorilio & Posso, 2010).

### 3.2.2 Summary of literature on FMEA

A summarizing matrix of what the literature state as important factors when using FMEA has been created and can be seen in Figure 3.1.

Area	Success factors	Source:	1	2	3	4	5	6	7	8	9
Knowledge	Training and education		X	X	X		X			X	
	Reapplication of knowledge						X		X		X
Attitude	Motivation and purpose		X	X		X		X			
Organization	Linkage to organization					X		X	X		
Resources	Sufficient amount of resources		X	X		X			X		
	Evaluation			X							
Practical usage	Scoring		X	X			X			X	
	Timing					X		X			
	Wording										X
	Team and meetings		X	X	X		X	X			

**Figure 3.1:** Summarizing matrix of literature on FMEA usage. Source: 1. Dale and Shaw (1990) 2. Johnson and Khan (2003) 3. Teng et al. (2006) 4. Teng and Ho (1996) 5. Estorilio and Posso (2010) 6. Aldridge et al. (1991) 7. Wirth et al. (1996) 8. Liu, You, et al. (2019) 9. Tumer et al. (2003)

As seen in the figure, training and education has been mentioned by a majority of the sources included in the matrix. This is also true for the category on teams and meetings. There seems to some uniformity that these factors are central in succeeding with the usage FMEA.

### 3.2.3 P-FMEA

As previously mentioned, there are a variety of FMEAs being used today, and two of the most common in practical use are D-FMEA and P-FMEA (Dale & Shaw, 1990; Madzík & Kormanec, 2020). In the P-FMEA, the aim is to identify faults that might occur from the product not being manufactured according to its specification, for example due to machine variations or operators misassembling parts (Aldridge et al., 1991; Dale & Shaw, 1990).

The aim of the P-FMEA is to identify the process characteristics that are critical to avoid failures, by using questions regarding the consequence of failure, probability of occurrence and probability of detection before they affect the customer (de Aguiar, Salomon, & Mello, 2015). Consequently the relationship between the severity of the failure, how easy it can be detected and with which frequency it occurs is what the P-FMEA tries to investigate.

The P-FMEA-process starts with selection of the team since they are responsible for conducting the analysis and should consist of people from different functions in order to have different perspectives during the analysis. These functions are according to Stamatis (2013) usually:

- Quality Engineer
- Reliability Engineer
- Tooling Engineer
- Process Engineer
- Design Engineer
- Responsible operators from all shifts

With optional attendance from people from these functions:

- Marketing
- Material Engineer
- Field Service Engineer
- Product Engineer

The P-FMEA starts with producing a process flow chart/function analysis in order to get an holistic understanding of how the specific part or product should be manufactured (Teng & Ho, 1996). This process should then yield the desired process steps for the specific product and when the different function steps have been identified the analysis can begin.

The team is responsible for investigating this in the analysis part and this whole part is usually recorded with a standard form. An example form can be seen in Figure 3.2

The team then starts to analyze the Failure Mode (FM) of each function, a FM is defined in the AIAG-VDA handbook as “... *the manner in which the process could cause the product not to deliver or provide the intended function*”(Automotive Industry Action Group and Verband der Automobilindustrie, 2019, p. 96). Examples of a FM are: Dirty surface, hole too shallow and barcode not readable.

### 3. Frame of Reference

Process name:			Involvement of others:			Key prod. date:									
Part name:			Supplier involvement:			Prepared by:									
Mfg or design responsibility:			Model/product:			FMEA date:									
Person responsible:			Engineering release date:			FMEA review date:									
Page			of			pages									
Process function	Potential failure mode	Potential effect(s) of failure	SEV	Potential cause(s) of failure	OC	Detection method	DET	RPN	Recommended actions	Individual /area responsible and completion date	Action taken	S E V	O C C	D E T	R E P
Approval signatures:									Concurring signatures:						

**Figure 3.2:** P-FMEA adapted from Stamatis (2013)

Then it is time to list the Failure Cause (FC), and it is defined by its relationship to the FM. The FM is the consequence of the FC, hence the FC is an indicator why a FM could happen. These are typically analyzed but not limited by Ishikawa's 4M, and they are listed below together with a few examples (Automotive Industry Action Group and Verband der Automobilindustrie, 2019):

- **Man** - Machine operator, assembler, technician
- **Machine** - Robot, conveyor, tanks
- **Material** - Machning oil, grease
- **EnvironMent** - Heat, lighting, noise

The third thing the team needs to assess is the Failure Effect (FE) and it is described in terms of what the customer might experience or notice (Automotive Industry Action Group and Verband der Automobilindustrie, 2019). Customers in this case could be both internal and external customers, legislative bodies, and product end user/operator (Automotive Industry Action Group and Verband der Automobilindustrie, 2019). Examples of these are: unable to assemble, noise, odor, or cannot control.

When the team have defined all the FM, FC and FE, the P-FMEA-process is ready for then risk analysis step. In this step, the FM, FC and FE are usually evaluated and graded using the RPN (de Aguiar et al., 2015). S stands for the severity of the FE, O stands for the occurrence of the FC and D stands for the detection of FC and/or FM (de Aguiar et al., 2015). These are ranked from 1-10, and the team conducting the analysis is responsible for assessing which value each of the SOD-

ratings should have. There is plenty of examples and tables in books and standards which can guide the team in assessing the ratings more correctly. The three numbers are multiplied and the total RPN-value directs the team to the failures that should be dealt with and indicates which should not be prioritized. These are listed in a control plan where corrective actions are listed in order to deal with the identified problems.

The P-FMEA is usually performed at the development of a new product, but the document also needs to be updated. This is usually triggered by three different events (Teng et al., 2006):

1. Products design is changed
2. New failure mode is identified
3. An error proofing design is implemented

### **3.3 Implementing Quality Tools and Practices**

Implementation in this context means the practice of planing for and starting to use a new tool or practice. A successful implementation concerns an implementation were the new or updated practice reaches all those concerned by it and that the practice is still used in a long term perspective. This section describes a number of factors that have been identified as important when implementing new quality tools/practices as well as sustaining them. The broad range of sources covers general implementation and change as well as implementation of specific quality management systems and tools, such as TQM, Six Sigma and Lean. Even if the focus of this research is on FMEA, literature covering implementation of other quality tools and practices are included since they require similar capabilities. Many researchers have studied similar methods; Netland (2016) studied CSF of TQM, Six Sigma, Total Productive Maintenance (TPM), Just-in-time (JIT), and CSF for Lean and Done et al. (2011) included studies of TQM, general change, and Lean in their attempt to find factors influencing the sustainability of BPIs. Moreover, FMEA can be part of TQM (Johnson & Khan, 2003) and using several sources on implementation and sustaining TQM is therefore justified. Many authors have concluded that similar topics are important and the most common themes will be highlighted in Figure 3.3 at the end of the section.

#### **Leadership**

When implementing new tools and management systems, leadership, management support and engagement is crucial. To achieve sustained organizational change, managerial style, approach, preferences and behaviors seem to matter (Buchanan et al., 2005). Warwood and Roberts (2004) state that effective leadership is the most

important factor when it comes to implementing TQM. Commitment and involvement of senior management is also an important factor in making implementations persist and flourish (Coronado & Antony, 2002; Netland, 2016). Furthermore, in reviewing how employees assess senior management commitment, factors such as what they say and do, time spent attending quality meetings and reviewing quality, and the resources commitment have been identified (Venkateswarlu & Nilakant, 2005). This indicates that the role of management matters a lot when it comes to reaching success with implementations.

Dale et al. (1997) list a number of factors that impact the sustainability of TQM implementation, and senior management and management commitment play a major role. They list for example management commitment. Bunney and Dale (1997) write that management's understanding of the tools is vital for success of quality tool implementation. Beyond senior management commitment, Dale et al. (1997) emphasizes the need of vision, support and direction as well as common goals from senior management. The relationship between management and the rest of the company can also impact the sustainability of the implementation. There is need for a consistent management style that focuses on teamwork. A lack of confidence in senior management can be the result of previous implementation failures and inconsistencies (Dale et al., 1997) and this can harm future implementations. Done et al. (2011) have examined how BPIs can be sustained in the long run, and a number of factors are investigated, many that connects to leadership and management. Done et al. (2011) state that a clearly communicated strategy and objectives for change are important. The readiness for change and making sure that members of the organization and stakeholders are committing to the change also matters (Done et al., 2011).

#### **Organizational**

Many factors connected to implementing and sustaining quality are closely related to the organization and its structure. Coronado and Antony (2002) describe that in order to implement Six Sigma in any organization there is a need for some organizational structures to be in place, for instance, to have some degree of communication skills, long-term focus/strategy and teamwork. Another aspect of the organizational structure is how policies are set within the company. Dale et al. (1997) describe that policies in general can cause barriers for the success of the implementation, so it is important that the policies set promote the intention of the change (Buchanan et al., 2005). Beer, Eisenstat, and Spector (1990a) state in their paper about why change-programs do not produce any change that it is important for polices to be set after the change is initiated to facilitate sustainability of the change initiative. An example is given:

*“Navigation boosted its profits without changing reporting relationships, evaluation procedures, or compensation. Only then did the general manager alter formal structures; e.g., eliminating a VP so that engineering*

*and manufacturing reported directly to him.*" (Beer et al., 1990a, p. 1)

This is also emphasized by Kotter (1995) who promotes the importance of institutionalizing change so that people do not start to go back to how things were before the change when the pressure for it is gone. Anchoring and facilitating this behavior could be supported by policies promoting a new behavior. This indicates that policies have to be considered before the change to avoid barriers but also after so that the organization can sustain the change.

Continuing on resources, Dale et al. (1997) list a few factors influencing the integration and sustaining of TQM and one of the factors is lack of resources devoted to Quality Programs. Done et al. (2011) also describe resources but with the perspective of the competition BPIs have against the daily activities within the companies. This does not only concern financial resources but also other forms, such as human resources. Netland (2016) states that the project needs to have resources allocated to implement the full length of the change, but it is important to understand that this will require collateral changes since the change itself will not succeed if it is done in isolation (Venkateswarlu & Nilakant, 2005). Venkateswarlu and Nilakant (2005) describe collateral changes as changes that forces the organization to change in its core in order to support the new quality tool or system. Not integrating the methodology could lead to failure since some of the companies studied that implemented TQM in isolation generally failed to persist in their initiative and hence failed with the implementation in the long term.

Financial aspects is another factor influencing change connected to the organization (Buchanan et al., 2005; Warwood & Roberts, 2004) and how the change is monitored (Bunney & Dale, 1997). Beer (2009) states that monitoring and measuring is crucial in order to improve and therefore, vital for companies wanting to achieve high performance and high commitment in their company. Done et al. (2011) listed a factor that only the most successful case company in their study had, which was to align the Key Performance Indicator (KPI) to the change initiative. They state that this facilitates short-term improvement as well as long-term sustained change. Bunney and Dale (1997) emphasized the importance of evaluating the process performance in order to improve continuously.

## **Knowledge**

When implementing a quality tool or practice, the knowledge of that tool seems to influence success (Coronado & Antony, 2002). For example, Buchanan et al. (2005) emphasize the importance of competence to sustain change. Done et al. (2011) write that the people responsible for the change must have knowledge of both the organization and the practice that is going to be implemented to achieve short and long term success and Bunney and Dale (1997) opine that the improvement teams might need specific training to ensure effective use of quality tools. It is also important to consider the education of the rest of the organization. Dale et al.

(1997) writes that

*“Attention is also required to the training which is required by individuals and a systematic method put into place to identify these needs” (p. 378).*

Warwood and Roberts (2004) include commitment and investment in training as a part of employee involvement, which influence the success of TQM implementation. Netland (2016) identifies training and education for both employees and managers as important factors to succeed with Lean implementation. Further, Bunney and Dale (1997) reckon that the timing of the training is essential. The training should be carried through just in time so that employees can test what they have learned soon after the training (Bunney & Dale, 1997).

Another aspect of knowledge concerns how organizations use knowledge to improve; Warwood and Roberts (2004) describe the importance of continuously applying and evaluating BP applications. BPs form the best way of doing the aimed methods/practices and having the theoretically best method/practice should therefore help the company to do better. But BP can change over time so it is important to revise them and apply the practices that are the current BP. As mentioned in the section on organizational aspects, Bunney and Dale (1997) state that evaluating and being aware of one's performance is important. This highlights the importance of using knowledge to keep improving. To summarize, there seems to be a need to invest in education in the quality tool or system that is being implemented to succeed with change.

#### **Individual**

Another subject which many factors regarding change and implementation of quality is closely connected to the individual. Buchanan et al. (2005) talk about the individual's fear of the change itself as an obstacle for the change, have the individuals accepted the normality of the fear in a change-process? This is explained as the “fear”-factor according to Dale et al. (1997), which continues to describe the consequences of fear, that the attitude changes and individuals shift their attitude to survival/ protectionist. Not knowing what your future holds causes you to take short-term decisions. In a study by Warwood and Roberts (2004) investigating TQM success factors, employee involvement was one out of the five most important ones. This connects to the fear itself, engaging and letting the employees being part of the change-process reduces the stress it causes. Bunney and Dale (1997) also describe a success factor connected to commitment, which is to practice patience and persistence in order to make effective use of tools and techniques.

Buchanan et al. (2005) conclude that cultural factors influence the sustainability of organizational change, and that it is important for the individuals of the organization to share beliefs, values and priorities. Kotter (1995) means that anchoring a change in the company culture is important to make new ways of working permanent

instead of just a temporary engagement. This is also emphasized by Venkateswarlu and Nilakant (2005) who state that companies often implement TQM as a ‘quick fix’ rather than as a culture change. To be able to succeed over time, the organizational culture must match the quality philosophy, otherwise employees might lose commitment (Beer, Eisenstat, & Spector, 1990b). Furthermore, Coronado and Antony (2002) describe the importance of culture when implementing Six Sigma. They maintain that people are afraid of the unknown when it comes to change, or do not understand the need for change. They propose education, communication and motivation to counter act these issues (Coronado & Antony, 2002).

### **Processual**

The actual implementation process has been discussed by several authors. Buchanan et al. (2005) identify the processual perspective as an important part of sustaining change, and it connects to the timing and flow of events and what implementation methods are used. Too slow or too fast change can both be problematic:

*“Change which is delayed may not deliver benefits. Change which is rushed may not allow time to adapt, and create initiative fatigue, encouraging decay”*(Buchanan et al., 2005, p. 202)

Done et al. (2011) describe that companies with change activities that happened in a planned, consistent sequence succeeded with their interventions in a long term perspective while those with poor handovers and discontinuous phases failed with their initiatives in the long run. Planning was also identified as a success factor when implementing Lean, where planning and follow up as well as setting targets were deemed central (Netland, 2016). Moreover, Beer et al. (1990b) find that the change process must be flexible and adjusted to problems encountered during the implementation. In implementing Six Sigma, Coronado and Antony (2002) raise the role of the project managers of the implementation. They are vital for the success of implementations. Other authors mention change champions as the leaders of the change (cf. (Done et al., 2011)) and their knowledge and suitability is important in change initiatives.

### **Political**

There seems to be factors connecting to the political perspective when discussing the aspect of sustaining change, one factor mentioned by Kotter (1995) is to enable action by removing barriers. Individual commitment aspects can create mental barriers, but sometimes the barriers are very real and not something found in someones head. Organizational structures and compensation systems are examples of this and the organization has to remove these barriers to facilitate the sustainability of the change (Kotter, 1995). Done et al. (2011) identified stakeholder management to be an important aspect of sustaining change as well. It was identified in cases where

*“constructive and open dialogue regarding the needs and expectations of the different stakeholder groups. In these cases, people resistant to change were identified and dealt with in a variety of ways. Such constructive dialogue and identification of stakeholder management issues was missing in other cases”* (Done et al., 2011, p. 507).

Buchanan et al. (2005) mention political aspects when describing factors influencing sustainability, it is stated that coalition power and influence could become barriers for the change, if they are not dealt with. Does the change have the support it needs from important stakeholders enabling it to sustain over time?

#### **Contextualization**

Venkateswarlu and Nilakant (2005) describe that even though a lot of companies try to implement quality management, a lot of efforts fail to persist and improvements programs become short-cycled. This is also discussed by Collins and Browning (2019) regarding Process Improvements Programs (PIP) such as Lean and Six Sigma; results are often inconsistent and tailoring PIP will improve adoption and increase effectiveness of the PIP implementation. BPIs are standardized to fit into most companies' contexts but organizations seem to struggle with integrating the practices and their methodologies throughout the company. Moreover, if the practices are not adapted to the core of the company, they will struggle to stick over time. Consequently, it will in the end be difficult to maintain the use of these practices. It is therefore crucial to contextualize so that the BPI will suit the company more (Done et al., 2011). Bunney and Dale (1997) state that having local examples that employees can associate with in training is a good practice in implementation of any quality tool.

It seems that the effective implementation of operations best practices is contingent upon the context (Sousa & Voss, 2008); how the method or practices fit into the context where it is applied needs to be considered. Warwood and Roberts (2004) state that a success factor for TQM is to be in a market where there is a fierce competition, thus forcing the companies to apply methods in order to improve. External conditions are also brought up by Buchanan et al. (2005), who linked it to context together with additional perspectives such as stability, threats and wider social norms which are highlighted as important for sustainability in change initiatives. Zairi and Alsughayir (2011) state that it is not sufficient with only the existence of CSFs in companies to be successful but there is a need to tailor the practice to specific organizational or cultural contexts.

### 3.3.1 Summary of Implementing Quality Tools and Practices

In order to have a more comprehensive understanding of what has been said, a summarizing matrix of what the literature state as important factors when implementing quality tools and practices has been created and can be seen in Figure 3.3

Area	Success factors	Source:	1	2	3	4	5	6	7	8
Leadership	Commitment, involvement and support		X		X	X		X	X	X
	Strategy, effectiveness and vision		X	X	X		X			
Organizational	Policies and structures		X	X						X
	Resources and collateral implementation		X	X		X			X	X
	Financial viability		X	X				X	X	
Knowledge	Training and competence		X	X	X		X	X	X	X
	Continuous improvement						X	X		
Individual	Employee commitment and motivation		X		X		X	X		X
	Influence of company culture		X		X	X				X
Processual	Planning, timing and pacing		X	X				X	X	X
	Change champion			X		X		X		
Political	Stakeholder management		X	X						
Contextual	Contextualized tools and methods		X	X				X		X
	Context and fit		X				X			

**Figure 3.3:** Summarizing matrix of implementing quality tools and practices. Source: 1. Buchanan et al. (2005) 2. Done et al. (2011) 3. Dale et al. (1997) 4. Venkateswarlu and Nilakant (2005) 5. Warwood and Roberts (2004) 6. Bunney and Dale (1997) 7. Netland (2016) 8. Coronado and Antony (2002)

Almost all authors included in the summary discuss training and competence as a critical success factor when implementing quality tools and practices. The area of leadership is also highlighted by many researchers and all cited sources mention at least one of the success factors connected to leadership.

### 3.4 Combining FMEA and Implementing Quality Tools and Practices

To summarize this chapter, the following section will combine the summaries from Subsections 3.1 and 3.3. This combined matrix can be viewed in Figure 3.4. It acts as a visual summary of what categories overlap in the previously described summaries. It acts as a hybrid version of the previously mentioned summaries (Figure 3.1 and 3.3). The categories will be discussed, sorted and formed into a theoretical framework. The framework can be used to asses companies in implementing the FMEA-tool.

		FMEA critical factors													
		Knowledge	Training and education	Replication of knowledge	Attitude	Motivation and purpose	Organization	Linkage to organization	Resources	Sufficient amount of resources	Practical usage	Scoring	Timing	Wordings	Team and meetings
<b>Implementing Quality</b>	<b>Leadership</b>	Commitment, involvement and support				X									
		Strategy, effectiveness and vision				X									
<b>Organizational</b>		Policies and structures					X	X				X	X		
		Resources and collateral implementation					X	X				X	X		
		Financial viability								X					
<b>Knowledge</b>		Training and competence	X								X	X			
		Continuous improvement		X						X					
<b>Individual</b>		Employee commitment and motivation				X									
		Influence of company culture				X									
<b>Processual</b>		Planning, timing and pacing													
		Change champion													
<b>Political</b>		Stakeholder management					X								
<b>Contextual</b>		Contextualized tools and methods										X	X	X	
		Context and fit				X									

**Figure 3.4:** Combination matrix of FMEA and implementing quality

The following sections will analyze this combination matrix to form a theoretical framework. The areas and factors from the implementing quality summary are used as a base, then each one will be discussed related to the factors in the FMEA summary. It will be discussed if they can remain the same or if they need to change due to differences in what the FMEA summary in Figure 3.1 states. If they do not correlate or have any similarities at all, new factors will be created. In the following sections, the new framework areas are marked in bold while the factors making up the theoretical framework (Figure 3.5) will be marked in italic.

#### **Leadership**

In the section on implementing quality tools and practices, leadership was found to play a vital role when it comes to succeeding with implementations. In the section on

FMEA, attitude was brought up, and a need for having a purpose other than satisfy customer requirements. Senior management therefore seems to need to be involved and set a vision that aligns with other purposes than just doing it for the customer, something that clarifies the value for the organization. The category of leadership will therefore be expanded to include setting vision *and* purpose. The framework will therefore include *Commitment, Involvement and Support*, and *Strategy, Vision and Purpose* as factors in the area **Leadership**.

### **Organizational**

Organizational factors were considered to affect both implementing quality tools and practices, and FMEA. In the summary of FMEA usage it was seen that it is important that the tool connects to other tools and the organization. This could be achieved by having policies on what these structures should look like. The connection to other tools could also be made through individuals acting as cross-functional links. Resources is another shared factor the two summaries have in common. Both of them discuss the fact that the implementation is dependent on having enough resources while the implementing quality also emphasizes on the collateral changes. Evaluation is brought up in the FMEA-summary and it links to financial viability in implementing quality, companies need to assess the situation today in order to know if the tool is a viable solution for them. Evaluating FMEA regarding how it has been performed, getting an indicator of the performance could also help to improve the performance of the tool. Another factor brought up by the FMEA-summary was that timing of the tool is important, this also links to policies and structures in implementing quality. How the tool is defined, when is it suppose to start and so on. The factor Team and meetings from the FMEA-summary is also linked to the policies and structures since it involves the procedure of the meetings, questions such as: when and how many meetings are required? Who should be in them? needs to be structured. Team and meetings are also connected to the organization since it is influenced by resources utilization.

To summarize, the factor *Policies and Structures, Resources and Collateral Implementation* covers the factors Linkage to organization, Sufficient amount of resources, timing and team & meetings. Financial viability covers the reason why the company should perform the analysis from a cost and resources perspective. However, other aspects of evaluating the FMEA also need to be taken into consideration, such as performance and continuous improvement. This makes it feasible to combine Evaluation from Figure 3.1 and Financial viability from Figure 3.3 into one new factor, which will be called *Viability*.

### **Knowledge**

Many of the researchers cited in Subsection 3.3 emphasized the importance of knowledge and training in the practice being implemented. It also became apparent in the subsection regarding FMEA that many organizations struggle with this and that re-

searchers deemed it central. Training the members of the organization in the method is therefore considered a critical factor when implementing FMEA. Training and education can also impact the practical usage of FMEA. By training members, the problems regarding scoring and subjectiveness can be minimized. Furthermore, by having common training, the practical problem of starting in time can be reduced, since the users of FMEA can have a common ground to plan from. Knowledge also concerns the application of best practices and continuous improvement. Earlier, the subject of reusing failure history was brought up, and a part of continuous improvement in FMEA would be to learn from previous FMEAs. Evaluation also has a strong connection to this subject, as it is important to understand when one performs a successful FMEAs to keep getting better. The category knowledge from the FMEA summary in Figure 3.1 fits within the category of knowledge in implementing quality tools and practices, and that category also includes the aspects of evaluation of the tool and mitigating subjective scoring. Based in this, the factors that will be included in the framework are *Training and Competence* and *Continuous Improvement*.

#### **Individual**

The category individual covers both individual commitment and the influence of company culture. Both of these connect to the aspect of motivation and purpose from FMEA challenges, since they concern why individuals perform FMEA and what they consider the purpose to be. It therefore seem important to focus on having a clear purpose and understand why a company performs FMEA as an individual, and this is partly done through what the company culture emphasizes. *Company Culture* will therefore be included in the framework. The leadership factors (*Commitment, Involvement and Support*, and *Strategy, Vision and Purpose*) described above cover the motivation and purpose concerning senior management. However, *Employee Commitment and Motivation* covers the motivation and purpose of the employees.

#### **Processual**

The processual section covers how the actual change happens. It does not clearly connect to any factors identified as challenging with FMEA but it is still important. To have a plan, a change champion and consider the flow of event seem important in any change and for FMEA it could mean the pacing of other important aspects, such as training and discussing the purpose. The change champions can spread the new ways of working throughout the company. *Planning, Timing and Pacing* and *Change Champion* will therefore be included in the framework.

#### **Political**

There is a connection between the two summaries (Figure 3.1 and 3.3) regarding political factors. Implementing quality tools and practices points out the importance of stakeholder management, while the FMEA-summary emphasizes the importance

of linking the tool to the organization. Stakeholders interested in the FMEA should be able to connect to what the progress is, what was found in the analysis and so on. This linkage and connection is crucial for the success of an FMEA implementation. *Stakeholder Management* will remain as a factor since the other aspects of Linkage to the organization is covered by the organizational factors. Since the factor is the only one in the area Political, the area will instead be called **Stakeholder Management** and include no other factors.

### **Contextual**

This topic is one of the factors that the two summaries have the most in common. Implementing quality tools and practices emphasizes the importance of contextualizing the tools and their usage. The FMEA-summary states that adaptations of the tool are needed to facilitate the implementation. Scoring, Wording and Team and Meetings are all factors that could be important to adapt so that they will fit better into the organization. As previously mentioned, BPIs need to be adapted into the context of the organization and contextualizing tools and methods is big a part of BPIs.

Context and fit is the last factor in the summary on implementing quality tools and practices (Figure 3.3) and this is an important factor influencing the implementation since it takes the external considerations into account. This links to what the purpose of using the tool is and for example customer requirements could be one of those external forces.

To summarize, *Contextualized Tools and Methods* covers Scoring, Wording and Team and Meetings. *Context and Fit* covers Motivation and purpose somewhat, however most of that is covered by the Leadership and Individual factors.

### **Effective FMEA Practice**

When success factors of using the FMEA as a tool were investigated, a few of them pointed toward things related to the practical usage. Some of the literature lifted factors related to the team, scoring and others which aim is to raise the quality and effectiveness of the tool. Most of the literature involves factors regarding the implementation, but having an efficient way of working with the tool will not limit the implementation, it will rather help the ones using it every day believe the tool is useful which promotes motivation. Hence, this area is considered to be needed in the framework. Since none on the areas in the summary of implementing quality tools and practices really includes this topic, the framework has to be extended with a new area that will be called **Effective FMEA Practice**. It includes no other factor and points toward using guidelines in the practices that promotes effective usage. This area links to what the FMEA summary states regarding scoring, timing, wording, team and meetings.

### Framework for Implementing FMEA

Based on the findings in the literature regarding challenges with FMEA, implementing quality and the categories above a number of factors have been summarized in the framework seen in Figure 3.5 and it includes factors that may impact the implementation of FMEA.

<b>Implementing FMEA</b>	
<b>Area</b>	<b>Success factors</b>
<b>Leadership</b>	Commitment, involvement and support  Strategy, vision and <b>purpose</b>
<b>Organizational</b>	Policies and structures  Resources and collateral implementation  <b>Viability</b>
<b>Knowledge</b>	Training and competence  Continuous improvement
<b>Individual</b>	Employee commitment and motivation  Influence of company culture
<b>Processual</b>	Planning, timing and pacing  Change champion
<b>Stakeholder management</b>	
<b>Contextual</b>	Contextualized tools and methods  Context and fit
<b>Effective FMEA Practice</b>	

**Figure 3.5:** Theoretical framework for implementing FMEA.

# 4

## Setting

In this chapter the setting will be described. The case company will be briefly introduced, and their project system explained. The new AIAG-VDA handbook will also be expanded on, as well as how its scoring system differs from a standard FMEA.

### 4.1 Case Company

The case company is a European supplier to the automotive industry with products reaching markets across the world. It is a renowned brand with a reputation of delivering high-quality products and has because of this, a big share of the markets in some of their product categories. The company has around 3000 employees, with approximately 10 manufacturing plants found on three different continents. The strong position has enabled them to explore their vision and thus expand their product offerings so that they can reach a diverse set of markets. As a consequence, their product competes in different markets with different demands. In their main product category, they dominate the market and some customers actually let the case company produce their products for them. In other categories they have an established position where the focus on high-quality products continues to raise the annual market share.

The company manufactures most of their products and components inhouse. This is done in numerous factories across the globe enabling them to reach more markets and supply in a higher pace. The different sites focuses on different products and components. Some are plain manufacturing plants while others have their own research and development.

To meet quality demands from both production and customers, the company uses different kinds of quality tools. One of them is the FMEA. Since the company is a supplier to many car-manufacturers the company is also obligated use those tools in order to meet certain standards. A recently released handbook focusing on the FMEA within the car industry awoke a desire to improve the case-company's P-FMEA. Firstly, because P-FMEA was used differently across the sites and the

value-perception of the tool varied across the organization. Secondly, because the handbook itself will become a future requirement from the customers. As a consequence, the company started a global project to develop and implement an standardized P-FMEA that is used similarly across the entire organization and is aligned with the proposed way of working with the tool according to the handbook.

### 4.2 The Case Company Project System

The product development at the case company is described in their Project System. The Project System is divided into different phases with checkpoints between them. Phase A concerns the market research and at checkpoint A the development project officially starts. Phase B is focused on the product concept and at checkpoint B the concept is frozen. Phase C is where the design is created and at checkpoint C the design is frozen. The production process is the focus of phase D and at checkpoint D the product is released. The project ends one year after product release, at checkpoint E.

At checkpoint C there is a requirement to have a draft of the P-FMEA and at checkpoint D it should be revised. There is no requirement on when the P-FMEA needs to start, only that a draft needs to be completed at checkpoint C.

### 4.3 Master FMEA

The case company has a number of processes in which many different products are processed, thus it might not be necessary to create a unique P-FMEA document for each process for a given product. At some sites, they have created one FMEA that is called master FMEA that is a compilation of these processes. The master FMEA includes a number of questions that should be asked for every product regarding what can go wrong for that particular product.

### 4.4 The AIAG-VDA Handbook

FMEA has been widely applied in the automotive sector and Original Equipment Manufacturers (OEM) often put the tool as a requirement on their suppliers. The OEMs saw an opportunity to work collaboratively and help their suppliers to improve their quality work, by joining OEM, Tier 1 suppliers, government entities and individuals in academia to form organizations with the purpose to help the supply-chain become less complex and expensive (AIAG, n.d.). An example of this type of organization is the Automotive Industry Action Group in USA (AIAG) and in 1993, they released their *Failure Mode and Effects Analysis Reference Manual* for the first time (Kluse, 2018). AIAG is a non-for-profit group that aims to bring down complexity and cost in the automotive industry (AIAG, n.d.) and they have since 1993 released four versions of their standard (Kluse, 2018). The German counterpart to AIAG, Verband der Automobilindustrie (VDA) has also developed

guidelines for the usage of FMEA, and for suppliers active in both the German and the USA market, this has caused confusion (Kluse, 2020). To mitigate this, they joined forces in 2019 to create a common standard and handbook for FMEA - *the AIAG & VDA FMEA 1st edition Handbook* (Kluse, 2020). The handbook regulates how FMEA is implemented, and suppliers of the automotive industry are pressured to comply in order to stay on as suppliers. But why does organizations need this book of recommendations, can they not do it as they please? If a company wants become a supplier to the automotive industry, certain demands will be put on them. One of those is to fulfill the demands of the IATF-16949 standard which is the widely-used quality-management standard for suppliers in the automotive industry. Car-manufacturers can put customer-specific demands as requirements on their suppliers, and this is why the handbook becomes so important. The customer could demand that the FMEA-process must follow the recommendations within the handbook. Hence, the practical guide with recommendations becomes a specific requirement that involves steps and instructions that a company needs to follow. It can now be audited by the customers, making the steps crucial to follow in order to not lose the IATF-16949 certification. If the company loses that, they cannot deliver their products to the automotive industry.

The AIAG-VDA handbook is the first of its kind since its the first time the two organizations collaborated. But each organizations has created earlier versions independently, four versions each (AIAG, n.d.; VDA, n.d.). The organizations work together with the OEMs and their Tier 1 suppliers to form guidelines to fit their operations. The new handbook addresses 3 different FMEAs (D-FMEA, P-FMEA and Supplemental-FMEA) (Automotive Industry Action Group and Verband der Automobilindustrie, 2019). It begins by describing the FMEA basics with an introduction chapter, it then moves on with details on how to execute each FMEA in one chapter per tool.

Changes made from earlier versions are presented in the introduction chapter of the handbook. The major changes are that the FMEA process is now presented into a 7 step approach. They consists of Planning and Preparation, Structure analysis, Function analysis, Failure analysis, Risk analysis, Optimization and lastly Result documentation. These are also formed into 3 phases, System analysis which contains the first 3 steps, Failure analysis and Risk mitigation which contains the next 3 steps and lastly Risk communication which contains the last step.

#### **4.4.1 Risk Priority Number vs. Action Priority**

The severity rating of FMEA has also been revised because of issues with RPN. The previous rating consisted of the product of Severity (S), Occurrence (O) and Detection (D). They are assessed by the team conducting the P-FMEA analysis. When they have reached consensus, the numbers are multiplied together to form the RPN. In the new AIAG-VDA format, the RPN number is replaced by Action Priority Number (AP).

One of the problems with RPN is that it considers the three factors Severity (S), Occurrence (O) and Detection (D) as equally weighted (Liu, Wang, et al., 2019; Automotive Industry Action Group and Verband der Automobilindustrie, 2019). This causes some combinations to have the same RPN number but with different values on S, O and D. To demonstrate the problematic with this, an example will follow:

$$\text{Severity} * \text{Occurrence} * \text{Detection} = \text{Risk Priority Number} \quad (4.1)$$

$$8 * 2 * 2 = 32 \quad (4.2)$$

$$2 * 4 * 4 = 32 \quad (4.3)$$

Both end up with the same RPN so it can be challenging to decide which one to prioritize. Should it be the one that could cause someone to lose their life but is easy to detect and discover or should it be the one that happens regularly and is rather difficult to discover but does not cause that much danger? Deciding is difficult and companies struggle with this.

AP on the other hand considers Severity first, then Occurrence and last Detection. AP does not have a numerical value as an output, the SOD is instead translated into Priority High, Medium or Low. If a risk is considered Priority High then it **needs** to be taken care of, if it is considered Priority Medium then it **should** be taken care of and if it is considered Priority Low then it **could** be taken care of. In the table of AP included in the handbook, there is for every combination of SOD an AP-rating and if the S is very high, both O and D have to be low to reach an AP of Priority Medium or Low (Automotive Industry Action Group and Verband der Automobilindustrie, 2019). This mitigates the problem of failures with high severity getting low scores and no action since severity is always prioritized.

# 5

## Methods

In this chapter, the research strategy and design will be presented, as well as how data collection was performed. There will also be a discussion on research quality and ethics.

### 5.1 Research Strategy and Design

To understand the logic behind the choice of research strategy and design, there will first be an introduction to the role of theory and data in this thesis. The relationship of theory and empirical data has historically been divided into deductive and inductive, where deductive reasoning builds on a general theory leading to a specific conclusion (Mantere & Ketokivi, 2013), where a hypothesis can be rejected or conformed based on findings (Bell, Bryman, & Harley, 2019). Inductive reasoning on the other hand, takes specific observations or findings and try to generalize them (Mantere & Ketokivi, 2013). There is a third approach that relatively recently has grown in popularity - abductive reasoning (Bell et al., 2019). This approach is described by Mantere and Ketokivi (2013) as a way to theorize based on both observations and known theory, and Bell et al. (2019) explain it as working iteratively between theory and data to explain phenomena that have been observed. This research builds on an abductive approach as this allowed for observations and theory to be collected and compared back and forth to build understanding. This allows the researchers to follow paths identified during the actual research. As the purpose of this research is to understand what critical success factors there are when implementing a global FMEA standard, an abductive approach is suitable since the understanding needs to build on a combination of theory and empirical findings. The research has been allowed to follow paths identified along the way to explain and expand the concepts found in empirical studies but not identified in prior research.

Furthermore, the research was based on the ontological assumption of constructionism, meaning that the social phenomena as well as what they mean are being constantly accomplished by people (Bell et al., 2019). The epistemological position naturally follows as interpretivism, which allows a more subjective understanding of people and actions (Bell et al., 2019) and it is suitable since it allows for more

in-depth studies of context and circumstances around social realities (Alharahsheh & Pius, 2020). This allowed for the subjective views of different people to build a coherent view on what the critical success factors are when implementing FMEA.

The research strategy is the broad orientation of the research and it should consider the theoretical positions of the research (Bell et al., 2019). Based on the positions described above, a qualitative strategy were most appropriate, since it allowed a focus on how individuals understand their social world and constant change of the social reality (Bell et al., 2019). The research questions are exploratory in nature since their focus is on identifying and exploring critical success factors, leading to an exploratory approach to the research. To allow for this exploration, the research design is what Yin (2014) describes as a single case study. This design was also chosen based on a revelatory case (Yin, 2014), since the researchers had unique access to a company transitioning to a new global FMEA approach which therefore allowed for the opportunity to study relevant factors when implementing the new standardized FMEA.

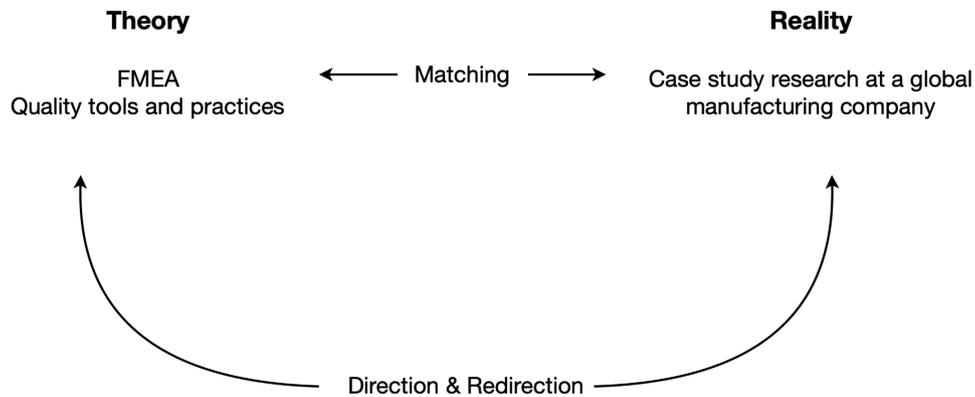
The thesis has focused on some aspects that put demands on which case company could be studied. The first demand was the new AIAG-VDA format, and this could only be found in the automotive industry so the case company needed to be from that sector. The company also had to have manufacturing facilities in multiple countries in order to make sure the thesis includes a global perspective. These requirements were fulfilled in the company studied.

### 5.2 Research Process

As studies of previous research and theories was running in parallel with the empirical fieldwork, conditions may change and findings may force the work to move in a different direction than what was thought of in the beginning. Consequently, the research process needed to have a non-linear formation. This is because linear and replicative research formulate boundaries and scope at the outset of the study causing deep structures more difficult to accomplish than non-linear (Dubois & Gadde, 2014). This means that the boundaries of the thesis' scope could not be set from the beginning but was instead reoriented to achieve deep structure instead of surface structure (Dubois & Gadde, 2014). These terms were coined by Chomsky (1971) and deep structure refers to soft terms such as thoughts, ideas and feelings whereas surface structure refers to the words or language used to express the deep structure. It is difficult to achieve deep structure, since this is where the underlining structure moves from being a description of the problem to an explanation (Dubois & Gadde, 2014).

The “systematic combining” is a research approach coined by Dubois and Gadde (2002) and describes a process where *“the research issues and the analytical framework are successively reoriented when they are confronted with the empirical world”*(Dubois

& Gadde, 2002, p. 554). This thesis is based on a single-case design with abductive reasoning which align with this thesis' purpose. Systematic combining involves two processes, **Matching**, and **Direction & Redirection**. This relationship is shown in Figure 5.1



**Figure 5.1:** Systematic combining adapted from Dubois and Gadde (2002)

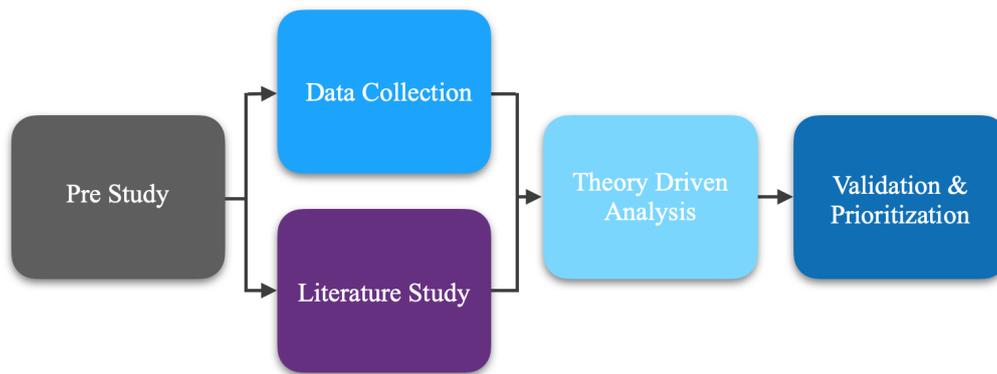
**Matching** is described as the process of going back and forth between the initial framework of the research, the data sources used to explore the ongoing hypothesis, and the analysis. It is simply trying to match theory to reality (Dubois & Gadde, 2002). **Direction & redirection** is important to achieve the matching process since it brings forward the aspect of verification. Case studies tend to use multiple data sources to verify the findings but in systematic combining, multiple data sources instead focus on helping the researcher to uncover dimensions that one source would not have revealed itself, this leads to discoveries of new dimensions of the research problem (Dubois & Gadde, 2002). This could influence the research to take another direction (hence the name) by going back and forth between the theoretical and empirical findings to explore new dimensions of the topic.

This research approach has been applied throughout the thesis work and could be demonstrated by giving a few examples. The target of identifying critical success factors was originally set to the P-FMEA alone. But after a while, the research redirected to include success factors from other FMEAs as well since many of the factors could be applicable in most FMEAs due to the similarities between them. Another example was that the interviewees pointed to another dimension which was not discussed to a great extent in the literature, this new dimension was the evaluation of FMEA. There was limited research of this but it seemed to affect the usage of the tool a lot. So further research was conducted into that topic. Lastly, a workshop was planned to be executed at the end of the research in order to revise the findings, the purpose was for the company to test the factors found in our research and evaluate if they worked or not. But the findings focused more on long-term implementations and testing them would be difficult within the scope of the thesis. Instead, verification was executed in a presentation-round where interviewees and members from the global P-FMEA project could verify the findings or falsify

them. The findings and implications were then prioritized in a feasibility and impact workshop so that the case company would know what recommendations to start with.

### 5.2.1 Timeline

The research was conducted in a structured way as can be seen in Figure 5.2. The research started with a pre-study where scope and limitations were set. It then moved into a literature and data collection phase which were conducted simultaneously and iteratively in order to be able to direct the literature search if the data pointed to new dimensions. Findings from the literature were used as input to the interview phase. The results from the interviews were then analyzed in a theory-driven analysis where findings from the interviews, observations and the literature were compared in order to find conclusions. These conclusions were then validated and verified at the case company and as a final step, a review of the recommended actions was performed. This step was conducted to prioritize the actions for the case company in order to focus resources on the recommendations perceived as most valuable for them.



**Figure 5.2:** Research process

The literature and empirical studies were performed in parallel, constantly comparing results and influencing each other to point the research toward insights and ideas that would be valuable in order to answer the research questions. This is a method of using more sources than one and comparing the result with one another is called triangulation (Dubois & Gadde, 2002).

## 5.3 Literature Study

Since the literature study was secondary to the pre-study phase, it started with conditions and boundaries found from that phase. Findings from that were, firstly, that the P-FMEA was not covered in the literature to the extent that the thesis work required, and this expanded the research to cover other forms of FMEAs such as mainly D-FMEA and System-FMEA. Secondly, since the research regards the implementation of the P-FMEA, the literature study also needed to focus on the

implementation of quality tools and practices. Lastly, any form of a new initiative or change of practice is going to have issues related to the change itself. Hence, research regarding change management had to be included to understand how that will affect the implementation process.

The research focused on scientific articles and books mainly found from searching the Chalmers Library Database (EBSCO) but also other databases such as Google Scholar and Web of Science. The study included searches in specific journals as well, these were: International Journal of Quality & Reliability Management, Journal of Operations Management and Total Quality Management & Business Excellence. The initial search-words given from the pre-study were: FMEA OR Failure Mode and Effects Analysis, Implement\*, Best practice, Change Management, Critical Success Factors OR CSF, Quality. However, as a consequence of the systematic combining method of constantly redirecting the research into new dimensions (Dubois & Gadde, 2002), the research shifted focus into new areas of exploration. If the iteration process directed the thesis work into another area, it forced the search-words to change along the way as well. For example, the area of taxonomy and classification of systems was something discovered in the process, hence new search words were introduced.

The snowballing search method was utilized by the researchers in order to deepen the analysis (Wohlin, 2014). Snowballing is described by Wohlin (2014) as *“using the reference list of a paper or the citations to the paper to identify additional papers.”* (p. 1). This led to the researchers finding new articles regarding the same topic or other interesting aspects.

## 5.4 Data Collection

The empirical data has been collected through interviews, observations at the case company - particularly at project meetings, and documents.

### 5.4.1 Interviews

The purposes of the interviews were mainly two, to explore dimensions that are not elaborated on in the literature and to deepen the understanding of FMEA by listening to people using it every day. There were several interviews conducted during the interview phase but a few informal ones were performed at the beginning of the project. They were performed with key informants and the purpose of them were to get an understanding of the methodology, the handbook, and the case company. The key informants were sampled based on convenience and contacted by the researchers when specific understandings were needed. One interview was conducted with an external researcher with many years of experience working with FMEAs. Another interview was performed with an auditor, who will audit the new AIAG-VDA standard when it is implemented at companies. The aim of this interview was to get an understanding of the new AIAG-VDA handbook and what it demands

from companies. Interviews were also performed initially at the case company with employees at Production Engineering in order to deepen the understanding of their specific situation, they were asked since they are usually responsible for conducting the P-FMEA. Customer relations were interviewed to understand how and why this new handbook has to be implemented according to the customers; how is the case company's current FMEA-work seen through the eyes of the customer.

After the literature study, the formal interview phase was initiated. To understand common perceptions and experiences among a group of individuals it was recommended by Guest, Bunce, and Johnson (2006) to involve a minimum of twelve interviewees and the thesis included fourteen individuals in case of someone opting out. The interviews were conducted as semi-structured ones since it promotes the opportunities of finding new dimensions which would be difficult find otherwise. This is as the interviewer can ask follow-up questions to explore certain answers further if something interesting is stated (Bell et al., 2019).

The interviews were conducted with fourteen different employees at the case company and in order to explore dimensions regarding differences between sites, employees from four different sites in three different countries were participating. However, the functional depth had to be explored as well since differences could occur within functions at one site. This forced the study to focus on one site with some input from other sites. Participants are shown in Table 5.1.

The interviews lasted from 1 hour to 1,5 hours, some of the interviews took more time (up to 2,5 hours in total) but they were divided into two occasions. Ethical aspects were considered in the interviews and these will be discussed in Section 5.6. The interview guide is shown in Appendix A.

**Table 5.1:** List of interviewees

<b>Site A</b>	<b>Site B</b>
<b>Position, Department</b>	
Global Director, Quality Department (I1)	Quality Manager, Quality Department (I9)
Production Engineering Manager, Production Engineering (I2)	Production Engineering Manager, Production Engineering (I10)
Senior Vice President, Supply Chain (I3)	
Quality Planner, Quality Department (I4)	
Manager D-FMEA Knowledge Team, R&D (I5)	
Director, Project Management (I6)	
Project Manager, Project Management (I7)	
Project Manager, Production Engineering (I8)	
<b>Site C</b>	<b>Site D</b>
Director, Quality Department (I11)	Quality Manager, Quality Department (I13)
Director, Production Engineering (I12)	Process Engineer, Production Engineering (I14)

### 5.4.2 Observations

Since this thesis was based on a single case study, collecting the data could be done in more ways than interviewing the employees. Observations is an alternative and this thesis had a lot of occasions where observations were made. The case company had global meetings about P-FMEA every-other week where the researchers could observe and take notes regarding the topics discussed. The role of the researcher was the observer-as-participant as defined by Gold (1957). This role is explained as the researcher or observer only having a minimal involvement in the social setting being studied. The researcher has some connection to the setting but is not naturally part of the social setting. During the meetings at the case company, the researchers mostly observed the conversations and took notes. These meeting notes were then used in the analysis.

Observations were made in other occasions as well for example, a physical visit at the nearest site and a live P-FMEA-meeting to get an understanding on how the analysis is currently performed at the case company. The role was still the same as in the meetings, the participants knew the researcher was there observing but they were not part of the analysis itself.

### 5.4.3 Document Analysis

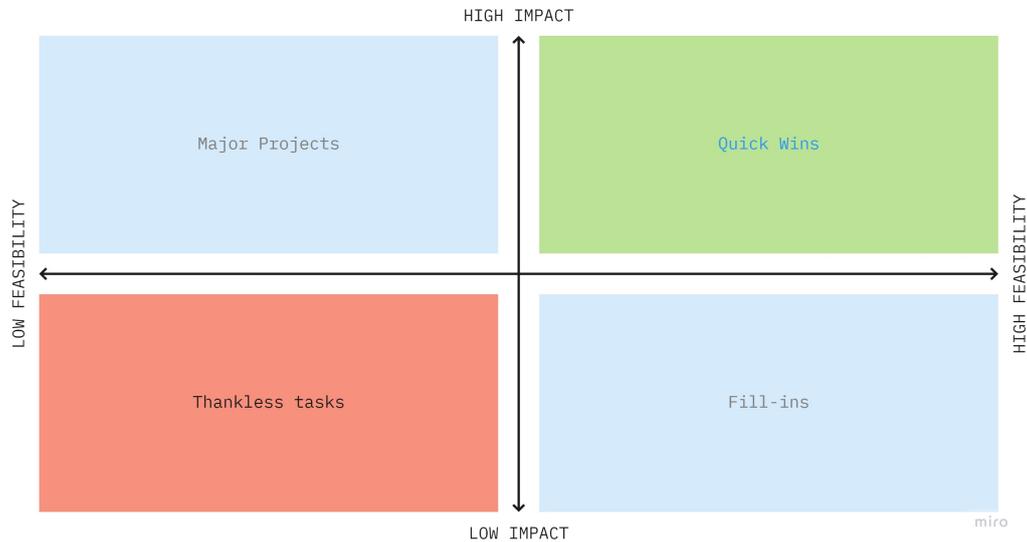
Bell et al. (2019) write that *“in case study[...] research, documents can provide the researcher with valuable background information about the company and its history”* (p. 505). The researchers studied a variety of organizational documents to understand how the P-FMEA was used and connected to other tools. These documents included project instructions, templates for P-FMEA, and instructions for how to perform FMEA.

### 5.4.4 Prioritization Workshop

The aim of the workshop was to prioritize the identified recommendations with the case company based on feasibility and impact. The purpose was to identify which recommendations the representatives from the company thought would have the highest effect on the organization, as well as how easy they would be to implement. The higher the impact, the more effect on the organization and the more feasible the easier to implement.

The attendees earlier participated as interviewees from sites A, B and C, and they were a global quality director, a local quality director, a local director of Process Engineering and a project manager from Process Engineering, from three different countries. The participants were chosen to achieve both a global and functional width. The workshop consisted of the researchers presenting the recommendations one by one, followed by the participants placing a virtual post-it on a virtual board containing a matrix with the axis impact and feasibility as seen in Figure 5.3. The quadrant with both high impact and high feasibility was called quick wins and the

one with low feasibility but still high impact major projects. The quadrant of low impact and high feasibility was called fill-ins while thankless tasks represented those with low feasibility and low impact.



**Figure 5.3:** Impact and Feasibility Matrix

## 5.5 Analysis Method

The general approach to the data analysis that has been used in this thesis was thematic analysis, which Bell et al. (2019) mean focuses on extracting themes from the data collected. This was done by going through the notes and collecting extracts on themes and opinions that people described. These were gathered as notes on a virtual board and grouped based on the themes that emerged through the notes. The notes were then grouped again into subgroups where this was possible. For example, some factors were identified that contribute to the success of P-FMEA. Some of these covered things such as being an active member, committing the time it takes or to be dedicated. These extracts were grouped into the sub-theme attitude.

This was done both for the observation notes and for the interview memos. The coding of the themes was similar to what Miles, Huberman, and Saldaña (2014) call provisional coding, where some categories that had been identified in the literature study were used as a starting list. The categories were then modified and expanded to suit the themes that emerged in the data.

## 5.6 Research Quality and Ethics

Trustworthiness of qualitative research can be divided into credibility, transferability, dependability, and confirmability (Guba, 1981). Credibility concerns if the research actually studies what it is intended to do (Shenton, 2004) and there are several strategies to increase this. Shenton (2004) describes many ways to do this, such as

using well-established research methods, triangulation or member checks. In this study, the use of case study methods, observations and semi-structured interviews align with Shenton's strategy regarding research methods, and triangulation has been done through interviewing participants from different functions at the same site, and the same functions at different sites. The member check consisted of the validation presentation, where the findings from the interviews were checked with several members of the organization to see if recognized the different views presented.

Since the research is a qualitative, revelatory, single case study generalization is not aimed for. Transferability can however be increased by giving details about the organization and data collection (Shenton, 2004). This type of information has been presented earlier in this chapter and in chapter 4, to allow for as much transferability as possible.

Dependability can partly be achieved by allowing for some kind of auditing of the research (Bell et al., 2019). Shenton (2004) opine that dependability can be increased by including sections on research design and implementation, operational details of data gathering, and reflective appraisal of the research, so this report includes such sections.

Confirmability concerns not letting personal values steer the course of the research (Bell et al., 2019). Triangulation, that was described to increase credibility, can have a positive impact on confirmability as well, as it reduces any effect of research bias (Shenton, 2004).

Since the research includes a collection of data through interviews, observations, and a workshop, care has been taken not to commit any ethical violations. Bell et al. (2019) discuss four ethical principles to consider in business research, namely avoidance of harm, informed consent, privacy, and preventing deception. Care has been taken to avoid causing harm by aiming for safe and open interviews where the interviewees could, in a non-stressful way, describe their work with P-FMEA. To ensure informed consent, the participants were informed of the purpose and aim of the interviews and that participating was voluntary. To ensure the participants' privacy the results from the interviews and workshop were anonymized. It was also made clear to the interviewees that they were under no obligation to answer questions that they did not want to answer. Lastly, to avoid deception, the participants were informed of what the research project was about.



# 6

## Empirical Findings

In this chapter, the empirical findings will be presented. As described in chapter 5, the data was thematically analyzed. Therefore, the empirical findings will be introduced in sections based on these themes.

### 6.1 Purpose and culture

Regarding the purpose of FMEA, there was a vast amount of different answers, 39 different ones. Many described the purpose from a manufacturing perspective, such as reaching manufacturing targets or finding faults in it. Others gave the perspective of the customer, that you need to use it because otherwise, it would be difficult to meet the customers' demands.

Quality was another reason for conducting the FMEA analysis, finding errors in the products in order to deliver the best possible products was explained as one of the most important aspects. Related to quality, others shared continuous improvements as a purpose since conducting the analysis helps the company to improve their processes and that is essential if you want to stay alive in the competition in the market.

However, some of the interviewees explained that there is a widespread belief that the tool is used as a “check in the box” exercise, a demand from the customers which is not producing any value for the company. One stated short and concise: *“It is considered as paperwork by [company] members. No value adding”* [I10]. Although, this was explained as a historical view and that they are moving away from that, some of them explained that this still exists. When asked why the interviewees had a different view than what they thought the rest of the company had, they explained that it was because they had seen the value of the tool as well as what can happen if it is not done properly.

Another aspect of purpose and motivation is attitude and it was considered to impact the success of P-FMEAs by many of the interviewees. One participant said that a good P-FMEA was achieved when *“those who work in the project also*

*have an understanding of what output it is suppose to give, why one performs a P-FMEA, why do one have use of it.” [I2]. FMEAs are considered less successful when they have been seen only as a paper product. As a success factor, interviewees mentioned the importance of having an open mind, to be an active member of the meetings, be meticulous and execute the actions that are identified in the analysis. As obstacles, people not showing up to meetings was mentioned, as well as not being engaged. Keeping production running has a higher priority, and sometimes someone just rushes through the P-FMEA right before a deadline without caring for the result.*

### 6.2 Evaluation

The interviewees were asked questions on how they evaluate the use of the tool and the most common answer was that they do not have any defined method to measure the success of the analysis. The amount of claims was explained as the only way you could determine it, but this is available first after a year. There was also someone describing that the overall gut-feeling of whether you did a good job or not was another way of knowing. When follow-up questions were asked on why there is no established way of evaluating the tool, the answer is that they would like to have it but do not believe there is a good way of doing it. One quality director answered *“from a quality perspective, it would be a dream to evaluate the process before for example checkpoint E” [I1].*

The interviewees were asked if they could come up with any alternative ways of evaluating the tool. A few examples were given and some of them were also used but not as a standard practice. These were for example reverse FMEAs, where you take the FMEA and do the process backwards to see whether the actions were dealt with or not. Another one was to go through and check whether you have satisfied the customer demands and lastly, if you have done an FMEA and could actually see that changes have been made to the process; that performing the analysis actually gave valuable input to the process and changes were made because of it.

There was also someone who talked about how you define success. If the D-FMEA is unsuccessful then the P-FMEA success would not matter and vice versa. But even a great D-FMEA and P-FMEA do not guarantee that you will not get any claims.

### 6.3 Knowledge

Knowledge was mentioned by several interviewees as something impacting how successful a P-FMEA is. It was described to be important to understand the problem and why you perform a P-FMEA and lack of knowledge was mentioned to result in bad P-FMEAs. Lack of competence and lack of experience in P-FMEA were described as obstacles. Knowledge of both the product and process were also brought up as things that impact success - one interviewee said that *“a good knowledge of the product” [I14]* is a success factor.

The knowledge on FMEA of the interviewees varied. Some had had external FMEA training and used it on previous jobs while others had limited training, mostly having learned by participating in P-FMEA meetings. Someone mentioned that without some sort of baseline knowledge, the performance of the P-FMEA becomes very different depending on the individuals performing it. Generally speaking, those that actually performed the P-FMEA lacked training in the method.

Many of the interviewees declared that it would be good to have a facilitator with great knowledge of the tool and how the different parts of the analysis fit together. Regarding how much knowledge the other members of the team need a few different views were presented. Many said that as a member you do not need much knowledge of the tool, but should instead have knowledge of your function/process and bring lessons learned. It can help to give new perspectives by including people with less knowledge of the tool. Others emphasize the need to understand why you are in the meeting and what you need to bring, *“You have to understand you know what I’m doing, why am I in this meeting, what is my role, what is my input here?”* [I12]. Currently, the knowledge is mostly spread by people attending the meetings. One interviewee said that training is important and emphasized the centrality of *“keeping that training up! [...] You need to continually use it and have training”* [I12]. Another interviewee that usually leads P-FMEA meetings answered the question if they think they have enough knowledge to perform their job as follows:

*“Yes, [laughs] it is a bit of both. I can say that one is kind of, self-taught or self-taught, [...] there have not been any outright educations in FMEA work at [the company], there are a few that I know have been away externally and, what to say, attended some education. But otherwise it is as, just like that have kind of joined FMEA and then started working more and more with it and that can be for better or worse but it results in kind of that there is, there is no base knowledge I would say, or it is above all a bit individual how the knowledge is and how one works with FMEAs. So it is pretty person dependent.”* [I8]

One interviewee thought that there was no good way to spread knowledge today and that this needed to improve. Some said that internal training would be an ideal solution and that not everyone needs external training. Master/family FMEA can also help spread knowledge, as well as a FMEA knowledge team. A knowledge team consists of a group of experts who work to spread knowledge and facilitate the usage of the tool. They could also act as the responsible team for the development of the the tool.

When it comes to the knowledge generated during the P-FMEA work the interviewees generally did not think they made good use of it but that it would be beneficial to do so. It was based on individuals remembering from one project to another, which was not seen as very quality assured. Some participants proposed a knowledge library or looking at master/old FMEAs or talking about it in daily

meetings as a way to improve the use of knowledge from previous P-FMEA.

### 6.4 Senior Management

The initial findings regarding this theme were observations at the case company. Senior managers seemed to be very supportive of the FMEA-work at the case company and this was then confirmed by key informants as well as most of the interviewees.

When asked about the commitment from senior management, many responded that they feel like the senior management supports the usage of the tool and share the belief of it being a good tool. However this was the opinions of interviewees from one site and the opinions were not consistent cross all sites. An interviewee representing another site stated that *“They are not bothering about any type of FMEA”* [I10] An interviewee representing a third site described it like the senior management have questioned their participation in the P-FMEA. *“Currently here, they think the P-FMEA is paperwork and someone else could do it,[...] it’s a waste of time”* [I12] They same person continued to describe that they would like to see senior management more involved in order for them to also see the benefits the tool gives. But there seems to be differences regarding what involvement senior management should have between sites as well. At another site, an additional opinion regarding the involvement was described, that senior management should not be involved in the process other than what they are today and this was a view shared by most of the interviewees from that site. Instead it was described that: *“the teams need to find how it works best and then senior management should just support it”* [I10]. This indicates inconsistencies of senior management involvement at different sites. So in short, it seems to be a coherent view on all sites that senior management is not involved in the process itself. However, there also seem to be differences regarding if senior management should be involved or not between the sites since one out of the four sites would not prefer them to be more involved.

Another shared view regarding the role of senior management was that there is a question of who should be responsible for the risks identified by the P-FMEA. When the analysis have been performed, some of the failures are taken care of while some are left, for example because they are not severe enough to require actions. Moreover, there is also the risk of missing out on identifying some of the possible failures. Some of the interviewees shared that senior management should take greater responsibility for the risks which are left in the product or processes.

*“The group should have the operational responsibility but then it should be given back to senior management, the responsibility, you do not get this today since the only question asked is if it’s performed or not”* [I1]

The person continues to explain that *“Senior management could not write off the responsibility even if they want to”* [I1]. The person points toward the legal aspect of being a senior manager, that they are legally responsible and accountable for the

potential problems their products could cause their customers.

An interviewee representing senior management shared their own view on their involvement and it was not different from the others. It was explained that they are not particularly involved in the P-FMEA today other than checking if it has been performed or not. The only time the P-FMEA is discussed at senior management level is when a major quality issue has occurred. However, the interviewee would like to be able to participate in the process more but explains that today it is quite complicated to understand the documents and would therefore like to see the P-FMEA summarized in a holistic and understandable way.

*“I think we could develop that, be clear with, there are these one, two, three, five things that are the most important on the product that we have identified and clearly defined way include it in the [project steering group] material. These are the things we see as risks with this product and we have made these actions to mitigate those risks. That’s where I think we could get better and then I do not want it like.., I want it in a simple understandable way as well and not detailed or complex but simply explained.” [I3]*

The interviewees were also asked about the stakeholders to the P-FMEA. As with the purpose, there were a lot of different answers. Many stated that the entire company should have an interest but most suggested that it should at least be Quality Department and Production Engineering. However, there were some that mentioned the customers, Senior Management and Logistics Department.

## 6.5 Responsibilities

The responsibility of performing the P-FMEA lied mostly with the project manager at Production Engineering, and it was moved to process engineers after 1 year. Many thought this was a good set-up. Some did bring up that the Quality Department should have greater ownership but one interviewee reasoned that

*“I would see that [...] quality maybe should have a bigger ownership in it, it is after all a quality control document [...] Much of the knowledge in a FMEA lies nevertheless, I would say, on the technical, at least on much of the we things we do at [the company] [...] how you kind of secure things in the machine and around the machine, there is maybe the most knowledge kind of among the technicians [at Production Engineering] ” [I8].*

So letting the Quality Department take over is argued to have its issues. The responsibility of making sure the P-FMEA is performed lies on the Project Manager of the whole project (not the project manager at Production Engineering) and one

interviewee thought that the Project Manager of the project should have greater ownership than just checking if the P-FMEA is done at all, since they are responsible for the quality of the whole project.

The responsibility of updating the P-FMEAs is another matter discussed by the interviewees. The participants generally did not think that the updating of the P-FMEAs worked well and some wish that this would be made more clear. Updating happened on three occasions: minor process changes, quality defects, or major product or process changes. Updating P-FMEA to accommodate minor changes worked badly and one interviewee described that when a process change takes 30 min, it is not so attractive to spend 1 hour to change the P-FMEA. There was also an observation that people who might want to look at, or update an old P-FMEA did not know where to find the files.

In the case of quality defects a problem of ownership might arise. The Quality Department owned the quality defect but Production Engineering owned the P-FMEA. It could be problematic if the Quality Department did not communicate/engage in the review of P-FMEA. A review of the quality defect handling process had helped, but the handover could still be challenging. Regarding the major changes, someone mentioned that there should be a requirement to review the P-FMEA, which it was not at the time.

### 6.6 Time

Starting the analysis in time has been brought up by interviewees as something done in successful P-FMEAs and it has worked well when one person has prepared the skeleton of the analysis before the meeting. Key informants state that a completed P-FMEA is required before Checkpoint C and that this is defined in the case company's Project System. However, a specific time for when the P-FMEA should start is not defined, only that it should be executed in Phase C and before Checkpoint C. According to the key informants the length of the phase varies so how much time you are given for completing the P-FMEA also varies.

In the interviews, questions were asked regarding the timeliness of the P-FMEA as well. For most of the questions, the interviewees' answers were similar to those of the key informants'; it starts in Phase C. However, there was a general perception that it would be beneficial if the P-FMEA work could start earlier. A few of the interviewees agreed that it could start as soon as the design concept is understood. *"As soon as you kinda know how the processing of these parts you can start looking at what could fail in this process"* [I12]. The P-FMEAs need to have been performed at the end of the Design engineering phase, at checkpoint C, and they have suffered if the analysis is started too late (close to Checkpoint C) or rushed through.

The actual trigger for the start seems to vary from project to project. New products are maybe forcing the P-FMEA to start earlier than in other cases for example

because specifications needs to be sent to machine manufacturers.

Many of the interviewees felt that they are given enough time for completing the P-FMEA. However, some of them highlight that they still end up in occasions where they started too late and get problems finalizing on time. *“It’s often completed last minute and it could be stressed because of that. You’re allowed to wait and then there is the risk of starting too late. Which could become a problem.”* [I4]. Some interviewees agreed but indicated that this is more of an common problem because of how the P-FMEA is structured at that specific site: *“Just how the project in [country] is organized. It starts too late, always no time for analysis”* [I14]. Others stated that keeping manufacturing going is considered to be more important than conducting the analysis so it is put a side until someone has time for it. However, a few opined that this is only a prioritization issue:

*“If you’re spending the time now to save your time later, you know pay me now and you will get the benefits later on. But it’s really just setting that commitment up front to be more proactive rather than the reactive later. But I think that is the biggest issue that I see here, you just go ‘I didn’t have the time right now’ but you won’t have the time later either”* [I11]

Someone else mentioned this aspect when asked if there is something hindering the completion of the P-FMEA:

*“..as everyone usually calls it resources, lack of resources, lack of time and I hate that expression so I will rephrase, this is about priorities, what you want to prioritize, do you want to prioritize and not conduct a good enough FMEA and risk doing it again, like what is it that makes you believe if you do not have time to do it right the first time what makes you believe you should be able to do it two times wrong or worst case 3 times wrong, 4, 5, 6 I can continue to rabble. They are clichés, standard clichés but they are so truthful that it is sick, so it’s simply a matter of prioritization, the only thing that can make us not succeed is if we start to lose management commitment and if we start to down-prioritize this work”* [I1]

There was also an aspect of time when the interviewees were asked about how they perform the analysis. They mentioned that a facilitator should be responsible for making sure the P-FMEA work sticks to the schedule and keeps to a reasonable level of detail to avoid, getting stuck in discussions. The facilitator should also be responsible for keeping the time of the meetings.

### 6.7 Connection to other tools

Many of the interviewees saw a connection between D-FMEA and P-FMEA and some said that the designers had been taking part in meetings to share their perspectives. The collaboration with the Design Department and the D-FMEA team was stated as a success factor; both as a way to challenge and improve the design, and to manage risks that the design itself cannot fix. Lack of information from the Design team and the D-FMEA was brought up as an obstacle to perform and complete the P-FMEA. When asked if they look at the D-FMEA when performing the P-FMEA one interviewee said that *“We try but sometimes we don’t even have this document”* [I14].

Moreover, many said that the connection is not strong enough today. It should be clearer what the key characteristics from the D-FMEA are. One interviewee thought that *“If we create the let’s say master FMEA then we do not pull out I would say we do not pull out data directly from the design-FMEA”* [I13]. Another said that it is currently *“a lone island to be honest. We have of course according to the book always the process-FMEA should be like a follow up of the D-FMEA but it is not.”* [I10] Some mentioned that Production Engineering should be part of the D-FMEA to defend the manufacturability, and that someone from the Design Department should have a similar role in the P-FMEA. One interviewee thought that it might become problematic if one of these sides (the Production and Design Departments) has too much to say. Interviewee 5 said that people from the Design Department and members from the D-FMEA team generally do not take part in P-FMEA but maintained that they could take part if the P-FMEA team thought that it would bring value.

A few of the interviewees did not think P-FMEA had clear connections to other tools and ways of working at all while others mentioned inputs as lessons learned and the knowledge in the group, product specifications, key points from D-FMEA and System-FMEA, flowchart and DfM (Design for Manufacturability). The outputs described were a control plan, the finished risk analysis, action plans, checks and balances and where to inspect.

### 6.8 Contextualizing

A key informant at the Production Engineering team stated that many adaptations could be made to the tool in order to make it more useful to them. These were small adjustments such as having a template with clear instructions, including a sorting function, and company specific examples regarding to the scoring process.

Questions about contextualization were also asked to the interviewees and the general opinion was that the tool was not particularly adapted to the organization. One person stated that it is *“not very adapted but that’s good since it should depend more on the people using it”* [I9]. With that said, the person refers to that it is up to the

people who use the tool everyday to make changes that fit their needs and because of that there should not be general adaptations. Most of them think is a good tool due to several reasons. They listed that the gate-structure with phases and checkpoints defined in their Project System as one reason since the P-FMEA fits naturally into phase C. Another reason was that their manufacturing moves more and more toward automated production which means they cannot afford late process changes to the same extent as small changes cause big ripple effects. Finding failures proactively will then become more and more crucial. However, a few listed the issue with the usage of a tool defined by the automotive standard.

*“[The company] is a company that is very quick-footed in making sure that things are done even when we have problems, [...], if you look at it historically that the P-FMEA and honestly the whole IATF audit has been particularly supportive in the way [the company] works because if you read the standard and then want to do something then it has to be like that for 10 years because if you change something you need to make so much paperwork if you want to move something 1 dm it’s ridiculous, especially as we work. In that way it does not support us at all” [I2].*

## 6.9 Practical usage

A few smaller themes have been grouped together into a practical theme, covering smaller things such as meetings and scoring as well as how the teams look.

### 6.9.1 Team

The team that performs the P-FMEA was mentioned to impact the success. One interviewee described an important project where the team caused issues:

*“we have not really defined properly the team members. That was so important project so everyone was involved in that project [...]. Too many people just wanted to be in the lead, so in the end the communication let’s say failed.” [I9]*

Others said that individuals doing it alone results in bad P-FMEAs. Having a facilitator and a cross functional team were mentioned as success factors.

In all sites, they include someone from the Quality Department and a process engineer in the team. Some functions that were common but not found in all teams were project managers from Production Engineering, sometimes someone from the production line was included. A few interviewees, but not all, argued that functions that should be included in a P-FMEA team were Maintenance, Design engineers, sometimes a site manager, and someone from the Testing Department. The directors of Quality Department, Production Engineering and Testing Department were described to be part of the analysis at one site and one interviewee said that “Of

*course Senior management is very welcome” [I13].*

In some cases, one person prepared the P-FMEA and it was then reviewed by the whole group. On all of the sites there was some who said that there were around 3-5 people at the meetings, while on site B there was one who said 1-2. So it seemed to be quite similar on all sites except for site B according to one interviewee. During the validation process, one participant that was not interviewed brought up that smaller sites do not have all the experts that might be found at bigger sites.

### 6.9.2 Scoring

A shared opinion was that the facilitator should be responsible for the team not getting stuck in the scoring process. Some described problems in understanding what the different Severity, Occurrence, and Detection points actually meant. A need to get clearer guidelines and examples regarding this was expressed by some. One person said that ranking detection was the most difficult to determine while another said that occurrence was the most difficult. A phenomenon of counting backward to reach a score that does not require actions was described to exist in the company. One person described how the company set points in two different ways: one where the team pushes down the number to make the risk seem alright, hence avoiding actions. The other version was where the team sets higher points until the opposite is proven, both these types were described. There were also some describing of ad hoc solutions to the scoring process within the teams, resulting in inconsistent FMEAs.

### 6.9.3 Level of detail

Regarding the level of detail, there were a variety of views. One interviewee described a weakness with their current, generic, master P-FMEA: *“the Master P-FMEA is too generic. And as a consequence it focuses on general risks related to most of the products but not on the specific ones” [I13].* It is mentioned that if it is too general, risks might slip through, and too much focus on general risks results in a lack of detailed analysis. As success factors, to be meticulous and actually do the actions that are identified in the analysis were mentioned. So some think that details are important but there are others who think that it is central not to focus on the details. Several bring up the P-FMEA as being too detailed resulting in too many FMEAs that are hard to complete and maintain, especially if many FMEAs concern the same process. Regarding previous P-FMEAs, one interviewee said that *“We were too detailed so it just took too much too long time in to finalize it and people were just bored to be honest. ” [I10]*

### 6.9.4 Wording

The final theme is regarding an aspect of misunderstandings, because if you write something down in the P-FMEA it is important how that definition is described in order to not form misunderstandings further along the way, for example when you

update the P-FMEA. The interviewees were asked questions on how they ensure what is written down does not get misunderstood later. The general opinion from them was that they consider the risk to always be there and that the only precaution taken is that you make sure everyone has understood what is said and written down. *“The group agrees on what you write down, that’s it”* [I2].

The observation during the interviews was that this topic had not been considered before so the interviewees struggled a bit to come up with answers related to this and that they did not really understand the meaning of it. They were also asked if they could list examples on how they could make sure that what is written down is understood. Some were given, for example it was expressed that if you have pictures it is easier to describe components. Part-numbers were also mentioned since using them could help specify what was meant, instead of referring to the screw, the FMEA team could specify exactly which screw they mean by using a part-number.



# 7

## Analysis

In this chapter, an analysis of the empirical findings based on the theory and framework in chapter 3 is presented. The analysis resulted in a number of recommendations (which are marked bold in the text) and these were also prioritized in a workshop with the case company focused on discussing the feasibility and impact of these recommendations. The findings from the workshop are presented at the end of the chapter.

### 7.1 Leadership

Leadership and the role of senior management have been highlighted by many researchers as impacting the success and sustainability of an implementation (cf. Coronado and Antony (2002), Netland (2016)).

#### 7.1.1 Commitment, Involvement and Support

In the literature, the commitment and support of management has been described to play a vital role in an implementation of quality practices and tools (Buchanan et al., 2005; Dale et al., 1997; Venkateswarlu & Nilakant, 2005) and management also needs to understand the tool that is to be implemented (Bunney & Dale, 1997).

At the case company, the commitment and support from management were inconsistent and some interviewees described how senior managers did not support the performance of P-FMEA at all. This indicates that the studied organization lacks in a consistent management support and understanding. However, at Site B, the interviewees described that they do not want too much involvement from senior management. *“the teams need to find how it works best and then senior management should just support it”* [I10]. This indicates that some participants felt that management can be too involved and that the people working with the tool should be left to find out how it best can be implemented, somewhat contrary to earlier research. So, management support is needed but, the involvement needs to be adapted to fit the individual site’s needs. Therefore, one recommendation for implementing P-FMEA is to make sure there is **senior management support at all sites**, and

to make sure that there is involvement when the participants and managers see the need for it.

FMEA is a time consuming tool (Teng & Ho, 1996; Wirth et al., 1996) and at the case company, interviewees described that P-FMEA work is down-prioritized compared to for example keeping production going. Some interviewees emphasized that lack of time to complete the P-FMEA really is a problem of prioritization; what to prioritize is a matter of what management decides prioritized if there is no time to complete all tasks. Therefore, it would be preferable if senior management **define how P-FMEA should be prioritized or not be de-prioritized.**

### 7.1.2 Strategy, Vision and Purpose

The literature on FMEA extensively discusses the purpose of performing the analysis, for example the importance of not only performing it for the sake of the customer or viewing it as a paper product (Aldridge et al., 1991; Johnson & Khan, 2003; Teng & Ho, 1996). In implementations of quality practices it is important for leaders to set the vision (Buchanan et al., 2005) and clearly communicate the objectives for a change (Done et al., 2011).

At the case company, the interviewees described 39 different purposes of performing P-FMEA, so they were not agreeing on what the purpose is. These different purposes were not necessarily bad (such as only viewing FMEA as something you do for a customer), but there was not predominant agreement on why the company performs P-FMEA. This indicates that the case company has similar problems as the participants in the study by Dale and Shaw (1990), where not understanding the purpose was highlighted as an issue many faced. Moreover, some of the interviewees described that the tool is still seen as a “check in the box” by parts of the company, contrary to what researchers advocate. These points indicate that the purpose of the P-FMEA has not been communicated clearly enough and that participants have been left to figure out their own purpose for performing P-FMEA. The first place to start to mitigate this issue is for senior management to **define a purpose** and make sure that all those taking part in performing P-FMEAs are aware of it.

## 7.2 Organizational

Organizational aspects have been proven to be important for implementing FMEAs, with factors regarding e.g. policies and structures (Coronado & Antony, 2002), resources (Dale et al., 1997) and viability (Beer, 2009; Done et al., 2011).

### 7.2.1 Policies and Structures

Policies and structure in this case, are meant to explain how companies have defined the “rules” for conducting the P-FMEA. The case company has performed P-FMEAs for many years, each site has performed it more or less in the way they believed was

best for them. This has resulted in that different rules of behavior are in place on the different sites. To achieve the goal of creating a global P-FMEA standard, the company needs to define rules of engagement on each site. These rules have to define the P-FMEA in detail by making it clear for everyone involved how it should be executed. Some areas with unclear descriptions and structures seemed to cause issues at the case company and these were identified as areas with lack of policies regarding timing, team, updating the P-FMEA, and how the P-FMEA connects to other tools or organizational functions. In order to not be affected by the issues, the case company must decide how these areas should be structured.

**Time policies** were considered to be required since the case company had problems with too late starts of the P-FMEA. The literature states that it is important to not start too late because then it will become difficult to make changes since the design or manufacturing process could have become more or less fixed (Aldridge et al., 1991; Teng & Ho, 1996). The only demand regarding timing for the P-FMEA at the case company was that it had to be finished before Checkpoint C. This caused the analysis to sometimes be postponed and down-prioritized until someone had time for it. The effect was that some P-FMEAs got rushed through and as a consequence the quality was affected since some possible failures were not identified. It appears that in projects where the P-FMEA has started early, the results have generally been better according to some of the interviewees. The company needs to define when and what should trigger the start of the P-FMEA, so that it could start as soon as possible. The literature also emphasizes on an iterative process in the early stages of the product life cycle (Aldridge et al., 1991). This is needed since the analysis can give early input to designers, it also promotes the manufacturability of the product, the iterative process puts an emphasis on an early start of the P-FMEA. How the start should be triggered is up to the company and what they consider to be a good trigger for them. However, the interviews did uncover that the start varies from project to project based on project size and complexity. This could mean that a universal trigger may be difficult to define. An alternative to the universal trigger is to define a trigger that varies by establishing it in the beginning of each P-FMEA in the so called P-FMEA planning phase defined in the handbook (Automotive Industry Action Group and Verband der Automobilindustrie, 2019). In this stage the purpose, boundaries and project plan is defined, so it could also be used to define what is needed to trigger the start of the P-FMEA analysis of each project.

**Team policies** have been discovered as a need at the case company since the sites do not have the same definition of how many or who should be included in the P-FMEA. Due to the unstructured setup, there have been occasions where one person completed the P-FMEA alone. Some of the sites also explained that they have had problems in motivating people to show up to the meetings, since there is no demand of them being in the P-FMEA meetings. How many meetings that are required for a P-FMEA in total was usually consistent on all of the sites but occasionally this varied as well. Having a clear description on who should be in the team and when would improve the quality of the P-FMEA since it forces the analysis to be

based on participation from the needed functions. Many authors emphasize on cross-functional collaborations and team effort when conducting the P-FMEA (Dale & Shaw, 1990; Estorilio & Posso, 2010; Johnson & Khan, 2003; Teng et al., 2006) so the case company must ensure to not end up in those situations where one or two people conduct the P-FMEA. How many participants and what functions are going to be discussed more in subsection 7.8.

One of the problems with the case company's P-FMEAs were that it was not considered to be a living document, contrary to what the literature state is important (Stamatis, 2013; Teng et al., 2006). During the interviews, there were some questions related to updating the P-FMEA. They revealed that the updating process did not work well, especially for the minor updates. Some of the interviewees stated that no clear description was defined on who is responsible for the updates. The interviews also revealed this to be a complex and difficult process since updating the documents after a minor process change could take more time than doing the actual adjustment in the process. This affected the motivation for the updating process and since no one was responsible for reviewing the process the quality of updating the document was affected. Because of this, there is a need to **define updating P-FMEA policies**. The policies should consider who is responsible, what type of update is required and when the updating process is needed, as well as the minimum requirements from an update, to avoid it being unnecessarily time consuming.

Another aspect brought up by the interviewees regarding the updating process was that they often have trouble finding old P-FMEA documents. The file system was not structured, which makes the updating process even more difficult. Beyond making the updating process difficult, the problem of not finding the P-FMEAs affected other processes as well. One of the things a P-FMEA team can do before they conduct the analysis is to review older P-FMEAs to find useful information. If the team cannot find the old P-FMEAs then they will miss out on lessons learned from similar projects. This could lead to that the team will avoid checking other P-FMEAs because it takes too much time finding them. The case company needs to **standardize where to save** the P-FMEAs.

One of the most discussed topics in the literature is how the P-FMEA interacts with other tools and functions. The case company does not appear to have a defined input/output to their P-FMEA, instead it is on some of the sites considered to be a lone island. This is far from what is recommended in the literature, in fact, it is rather the opposite. The links between P-FMEA and other tools need to be established to utilize the full potential of the P-FMEA (Teng & Ho, 1996). The case company needs to define what inputs are needed and how the links to other tools should look in practice. For example, should the interaction with the D-FMEA team consist of someone from each team taking part in each other's analysis or should the P-FMEA team be required to analyze the D-FMEA document. The collaborations and interactions could be defined in multiple ways, it is up to the case company how this should be defined since they have to establish what they can manage depending on capabilities and resources available. In short, the case

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company needs to **establish the connection to other tools and functions.**

### 7.2.2 Resources and Collateral Implementations

Making sure that the P-FMEA has access to the resources it requires has been highlighted as a crucial factor and the tool is considered to be laborious and time consuming (Teng & Ho, 1996; Wirth et al., 1996). Making sure that senior management support this aspect of letting the P-FMEA take time is important since the process cannot be rushed without affecting the quality of the P-FMEA. The case company has a large management support for P-FMEA, and for the majority of the sites this is not an issue. The case company seems to prioritize the quality of their products. They state that you cannot take shortcuts when it comes to quality, it will take the amount of resources it needs. This was also confirmed by the interviews since lack of resources was not mentioned as an issue, so it appears the P-FMEA is given the resources it needs. No observations have indicated that the P-FMEA was affected by a lack of resources either.

Collateral implementation concerns the aspect of not conducting change in isolation since it will affect the success of it (Venkateswarlu & Nilakant, 2005). Creating new policies and structures in order to make the P-FMEA fit the organization should therefore not be done in isolation either. Some policies, like how the P-FMEA connects to other tools will affect the structure of those tools. For example, the input to P-FMEA could be set to include a D-FMEA report. If the D-FMEA does not have a policy of summarizing the analysis into a report then maybe the P-FMEA policies will force new D-FMEA policies to be set. The case company needs to understand how the P-FMEA affect other tools when they establish the connection as mentioned in subsection 7.2.1 in order to facilitate the success of the P-FMEA. This should be considered when policies on how P-FMEA shall connect to other tools and functions are established.

### 7.2.3 Viability

The literature has discussed the aspect of monitoring, both as a method for continuous improvement (which will be discussed in subsection 7.3.2) and as a way to facilitate the change by aligning KPIs to the change initiative. Viability concerns the aspect of ensuring that the tool itself is viable to use. Does it give value today? Does the company get any benefits from it in its current format? The case company did to a large extent only evaluate the tool performance by checking how many claims each product received. There seems to be an interest in evaluating it further according to some of the interviewees but the knowledge on how to evaluate did not appear to exist. If the P-FMEA has been executed poorly, it will (in a worst case scenario) not be revealed until it has reached the customers. This puts a huge risk on the company's brand image. The recommendation is therefore to **establish a process to evaluate the P-FMEA** in short term as a compliment to their long term approach of checking for number of claims.

This could for example be achieved by creating some short term form of KPIs to measure the performance. The financial aspect is difficult to estimate since it is a proactive approach; it is impossible to estimate future savings. But the RPN could be used to form a KPI estimating the total change of the P-FMEA analysis. By comparing the total RPN before and after the P-FMEA it could give an indicator of how much change the analysis actually initiated in the process. This equation is shown in Equation 7.1. The value could over time become an indicator of the performance of the tool since the company could learn which values usually leads to good analysis.

$$\frac{(RPN_{before} + RPN_{after})}{RPN_{before}} = \text{Total RPN Change} \quad (7.1)$$

This could be complimented by a checklist of questions regarding if certain procedures have been performed or not. This could be checked at the end of the P-FMEA. Examples of these questions could be: Have the analysis used input from D-FMEA? Have the analysis started in time? Have the analysis included each required functions? and so on.

In conclusion, the P-FMEA has to be evaluated in more detail than what the case company currently does, what type of actions or how it is done is up to the company themselves since it should be something they consider to be value adding.

## 7.3 Knowledge

Knowledge plays a vital role in implementing FMEA. It has been highlighted by several authors, both those focusing solely on FMEA (Dale & Shaw, 1990; Estorilio & Posso, 2010; Teng et al., 2006) and those examining general implementation of quality practices (Coronado & Antony, 2002; Done et al., 2011; Netland, 2016).

### 7.3.1 Training and Competence

When implementing FMEA, training is central according to the literature on implementing quality practices (cf. Bunney and Dale (1997)) and that on effective FMEA usage (cf. Estorilio and Posso (2010)). At the case company however, most of the members of P-FMEA teams are not educated or trained in the tool. As one interviewee put it *“there is no base knowledge I would say”* [18]. The lack of knowledge and experience was also described as obstructing the success of P-FMEA. Johnson and Khan (2003) found in their study that the level of training varied a lot at the studied automotive suppliers, indicating that this problem can be found in other organizations as well. Since the literature and participants from the case company agreed that this is important for the success of P-FMEA, it would be helpful to create and **implement a training initiative**, to make clear how to perform P-FMEA. This would also be an opportunity to inform those who perform the P-FMEA of

the purpose for the company to perform FMEA, as mentioned in the section about leadership and setting vision, as well as the appropriate level of detail for the analysis. Moreover, any training in the tool should be given just in time to make sure the attendees can test their knowledge soon after the training (Bunney & Dale, 1997).

### 7.3.2 Continuous Improvement

In subsection 7.2.3 the importance of having **a process evaluating the P-FMEA** was mentioned for two reasons. The first has been discussed and the second reason is to be able to become better at what you do, i.e. continuous improvement. Bunney and Dale (1997) discuss the importance of evaluating the process performance in order to improve continuously. This connects to knowledge, by learning from what we do the organization can become better at doing it. The learning by doing approach used at the company is dependent on the individuals remembering each lesson learned from every P-FMEA. This is, as stated by one of the interviewees, not very quality assuring. Having a method/process to improve continuously is therefore recommended; making use of the lessons learned so that the performance and quality of the P-FMEA is improved. This could be achieved for example by making use of the FMEA Effectiveness Worksheet created by Pollock (2005). The worksheet evaluates the P-FMEA by analyzing it after a certain amount of time. Firstly, the failure modes and the effects from the claims that the product has received are listed. Secondly, the list is compared to the original P-FMEA list of failure modes and effects, analyzing why some failures have been listed in the failure modes from the claims but not in the original P-FMEA. Lastly, the team conducting the evaluating analysis can summarize the findings and share that with the organization in order to learn and improve future P-FMEAs. Since the FMEA Effectiveness Worksheet also evaluates the P-FMEA in a long term perspective, it could be used as an alternative to the ongoing long term evaluation of only checking for warranty claims.

The recommendations to the case company is to determine a system which **make use of lessons learned**. Solely depending on individuals remembering is not enough to promote organizational learning. A process that could aid is the FMEA Effectiveness Worksheet.

## 7.4 Individual

The employees that are impacted by a change can in turn have major impact on the sustainability of that change, for example their commitment (Buchanan et al., 2005) and involvement (Warwood & Roberts, 2004).

### 7.4.1 Employee Commitment and Motivation

The success of a change can be impacted by employees, fear for the change itself (Buchanan et al., 2005), fear can cause individuals to act defensively (Dale et al.,

1997). It is also central that people are committed to the change (Buchanan et al., 2005) and that employees are involved (Warwood & Roberts, 2004).

At the case company, no fear has been identified, they rather have the problem of people not caring or being bored. In the interviews, motivation for doing the P-FMEA was described as a success factor and many of the interviewees were committed to P-FMEA and the change. That being said, they also describe that the rest of the company might not share their view of the tool and that many, both managers and participants, see it only as a check in the box-exercise. The interviewees described that they reached their commitment through using the tool and really seeing the value of it. These insights need to be shared with the rest of the company to succeed with the implementation, it is not enough to only have some people that are committed, motivated and engaged. An important part of this is to make sure the organization agrees on the purpose, as described in section 7.1. To describe the value and why the company performs P-FMEA can be achieved through a training initiative, and it can also be used to build commitment with those performing P-FMEA.

### 7.4.2 Impact of Company Culture

The company culture can impact how individuals view the tool. It is central to share priorities and beliefs within the organization (Buchanan et al., 2005) and education and motivation can help avoid fear of change (Coronado & Antony, 2002). At the case company, the participants do not agree on why they perform P-FMEA. This issue with a lack of joint purpose can result in a challenge in anchoring the change, and to define the purpose as described in section 7.1 can help set a common view of tool. Clearly defining how the tool should be prioritized can also facilitated shared priorities and values. The interviewees also brought up factors such as how people act in the meetings and toward each other during P-FMEA work. They propose an open meeting culture where ideas are welcomed and where risks are valued higher until the opposite is proven. To achieve this, the company needs to establish the meeting culture they want, and spread it through training and meeting policies. Many of the interviewees saw a need for a company culture where proactive work is valued, as this quote exemplifies:

*“If you’re spending the time now to save your time later, you know pay me now and you will get the benefits later on. But it’s really just setting that commitment up front to be more proactive rather than the reactive later. But I think that is the biggest issue that I see here, you just go ‘I didn’t have the time right now’ but you won’t have the time later either”*  
[I11]

The participants have to understand that performing a good P-FMEA saves time later. These are examples of issues brought up at the case company that impact their motivation, the literature emphasizes the need for joint beliefs (Buchanan et al., 2005), but it does not state exactly what those beliefs should be for P-FMEA.

They need to be adapted to fit the individual organization and implementation.

## 7.5 Processual

How the actual implementation is planned and executed is important (Buchanan et al., 2005), to make the new P-FMEA practices sustainable.

### 7.5.1 Change Champion

Internal change champions are an important part of implementing quality practices (Done et al., 2011), and their experience can impact the success of the implementation (Venkateswarlu & Nilakant, 2005). The case company has not begun the roll out of the new P-FMEA method yet and the implementation has only been studied at a pilot phase, where templates and methods were developed, evaluated and revised. The global project meetings that have been attended to observe the company's P-FMEA project have members from most of the sites where the company has production, and uses P-FMEA. These individuals are engaged in the change initiative and represent the different sites. They are already acting as change champions but to facilitate the company wide implementation, their role needs to be more explicit. They should play active roles in implementing the new practices in all P-FMEAs at their site and help spread the culture and motivation required to succeed with P-FMEA. Therefore, it is recommended to **Establish change champions on all sites** and make sure these are widely known by the people impacted by the change. The change champions do not have to be the same people as those facilitating the actual P-FMEA meetings, since the role of the champion focuses more on implementation and spreading the word to the organization. There is, however, no problem if a change champion is also a facilitator.

### 7.5.2 Planning, Timing and Pacing

The planning, timing and pacing of an implementation is critical, Netland (2016) emphasizes having a plan and tracking the progress of it and Done et al. (2011) stress the importance of a well managed implementation. It was not clearly connected to any of the success factors identified in the literature regarding effective FMEA usage. However, since many of the factors described in this thesis resulted in recommendations, the implementation of these recommendations still need planning, prioritization, and pacing. With this in mind, the prioritization workshop was carried out to plan the implementation of P-FMEA and the aim is that the recommendations can be paced to avoid overwhelming the organization while still keeping momentum.

## 7.6 Stakeholder Management

Making sure that relevant stakeholders are involved in the P-FMEA has been discussed in the literature to be important for the sustainability of the change (Done

et al., 2011). For the change to remain, the actors involved in the process have to take part of it as well. For example, customers or senior management need to be able to take part in the process so that they can understand the value created. The case company does not appear to have a clear definition on whom their stakeholders are. The only clearly defined stakeholder who are rarely involved in the P-FMEA is senior management and their participation in the process is only making sure it is completed at a certain point in the project. According to the interviewees, there was a desire that senior management could participate in the process more but more importantly, take the responsibility back from the ones conducting the analysis. One way of doing that is to make sure they are informed on why some risks remain in the product and which risks have been taken care of. When they are informed on this, it could help them to take decisions regarding if the product is ready for launch or not. This could be realized through a so called FMEA-report as defined in the handbook (Automotive Industry Action Group and Verband der Automobilindustrie, 2019). The report's objective is to *"be a summary for the P-FMEA team and others to confirm completion of each of the tasks and review the results of the analysis"* (Automotive Industry Action Group and Verband der Automobilindustrie, 2019, p. 123). The handbook also states that the content of the documentation should include information useful for the intended reader. The layout should be company specific, this helps the company to form and use it in a way that they feel gives as much value as they need. The case company could use the **FMEA-report** as a tool for including stakeholders; summarize the findings and describe them in a level of detail which makes it easier for senior management or other stakeholders to understand what is recommended.

## 7.7 Contextual

The area of context and adaptation of implementations and practices have been brought up as critical (Benson et al., 1991; Brunet & New, 2003; Collins & Browning, 2019; Done et al., 2011). The tools and practices need to be adapted to fit the organizational or cultural context (Zairi & Alsughayir, 2011).

### 7.7.1 Contextualized Tools and Methods

One question related to the context is how well the tools and methods are adapted to the organization. It is stated in the literature that you cannot simply copy and paste methods or tools (Collins & Browning, 2019), they need to be contextualized to fit the organizational need. The case company does not have any examples on how they have contextualized P-FMEA. One interviewee mentioned that they see it as a BP and therefore believe it should be followed as it is. Done et al. (2011) emphasize that tailoring the BPI format to the specific context will help the organization to be successful. Tailoring usually involved *"modifying the scope of the intervention in terms of appropriate content, connected activities, a gradual involvement of stakeholder groups, a suitable format, duration and pace, a good location for workshops as well as other contextual aspects."* (Done et al., 2011, p. 507). An interviewee from one site mentioned the use of Master-FMEA as a way to

fit their operations better. There was no other clear example stated or found at the case company.

The goal of any implementation is to make sure that the new tool or method is integrated into the organization and sustained over time. A good way of doing that is to make sure that, in this case the tool, is adapted. As mentioned before, Bunney and Dale (1997) state that having local examples that employees can associate with in training is a good practice in implementation of any quality tool. When the interviewees were asked about examples on how they could adapt the tool to fit their needs, a few were given. One was company-specific examples to aid in the scoring process just like what the literature promotes (Bunney & Dale, 1997), another example was a sorting function, which filters out the highest rated risks. Both of these are examples on how to ensure the tool is adapted to fit their needs. The new AIAG-VDA handbook will make the tool even more complex than before since it includes more steps (Kluse, 2020). One of the interviewee stated that it feels like “*opening up a monster sometimes*” [I2], this is not something the P-FMEA team should feel about the tool. This increases the need to adapt the tool to ensure that it is not only regarded as a headache. The recommendation is therefore that the case company should **make adaptations to fit the capabilities of the different sites**. Some sites might have different needs and resources (such as human and financial resources) than others so it is therefore crucial that the tool can be adapted to each site while the core of the standardized template remains the same.

### 7.7.2 Context and Fit

The context and fit refers to how well the tool fits the case company’s way of working. For some companies the P-FMEA process might become difficult to integrate since the usage does not flow naturally with the rest of the operations. At the case company, it appears to fit their operations smoothly. Some of the interviewees explain that this is because of the gate-structure in the Project System. The use of checkpoints where certain criteria needs to be fulfilled ensures that the P-FMEA has access to the information needed. Another aspect was that the production is moving more and more toward automated manufacturing, thus increasing the need for a P-FMEA since making late changes in a automated process requires a lot of time and resources. The tool is undeniably needed and it also appears to fit the case company, therefore no recommendation will be made to the case company regarding this factor.

## 7.8 Effective FMEA Practice

The literature revealed certain FMEA techniques or actions which can be used to promote the effectiveness and quality of the analysis. One thing that is mentioned in the FMEA-literature is the use of a facilitator (Automotive Industry Action Group and Verband der Automobilindustrie, 2019; Stamatis, 2013). The function is to have someone that facilitates the quality and knowledge of the analysis. They should

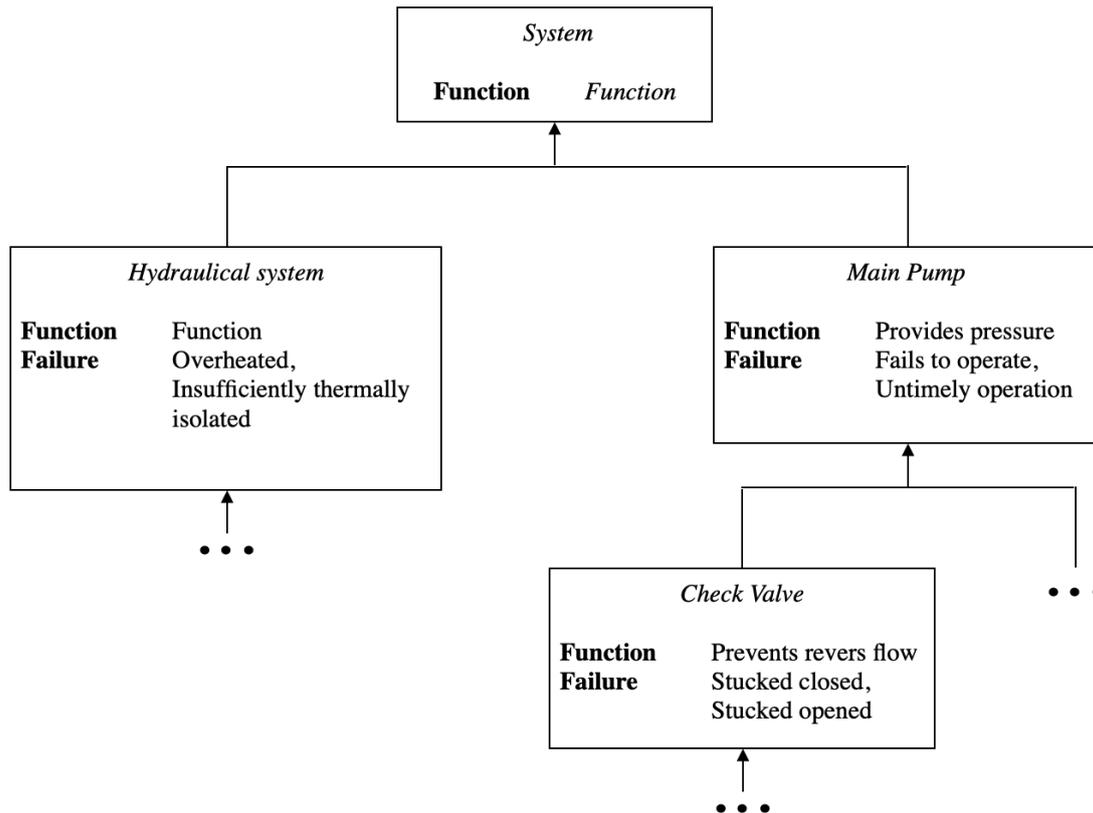
keep check of the FMEA procedures and make sure that the P-FMEA team does not get stuck on unimportant details. They should also act as a FMEA knowledge source. However, the one keeping the meeting going and the one with the great FMEA knowledge does not have to be the same person but it could be (Carlson, 2012). This basically means that the facilitator needs to have great knowledge of the tool and the methodology. Therefore, it could mean that the facilitator must be given access to a lot of different training, both internal and external. Many of the interviewees also brought up a facilitator with good knowledge of FMEA as a success factor. It does not appear to be any defined person acting as this function at any of the sites at the case company. With this in mind, the recommendation is that the case company **implement a facilitating role in their future P-FMEA meetings**.

The team has been discussed before regarding policies, but there are some more findings regarding the team which promote effectiveness and quality. At the case company, the P-FMEA team seem to usually be around 3-5 peoples from various functions but occasionally, there could also be less or more. It was stated that they have not defined who should be in the team properly. Due to this, the case company should **define team policies**; what functions need to be in the team? When do they need to be in the team? The team should consist of 5-9 people (Stamatis, 2013), it needs to be cross-functional collaborations (Liu, You, et al., 2019; Stamatis, 2013; Teng & Ho, 1996), and the group constellation should be the right mix of people since the size of the team needs to be restricted to the smallest possible number, otherwise decision making becomes protracted (Dale & Shaw, 1990).

One aspect that became obvious in the empirical study was that many of the interviewees mentioned issues related to the scoring process. These were things such as deciding whether if it was a 2 or a 3, counting RPN backwards to avoid having to take actions, unclear scoring examples or that the teams were made inconsistent judgments between different P-FMEAs and described that teams usually set some form of ad hoc agreements on how to score and these change from team to team. Due to the new AIAG-VDA handbook, many of the scoring issues will dealt with by using the AP system. Since the system gives High, Medium or Low risk as outcome and weighs Severity the highest, counting backwards will not be a problem anymore. The new AIAG-VDA examples for scoring got a great feedback from the company's D-FMEA team which had used it for a short amount of time. Many interviewees related issues with scoring to a lack of knowledge. The knowledge issues will not be dealt with the new handbook so integrating this in the training is important. Using the new handbook guideline will help the case company with their other scoring issues but they should be aware of the issues and take actions if the new AIAG-VDA guidelines do not seem to help. For example, if the new AIAG-VDA examples are not more helpful then the company might need to establish company-specific examples instead.

One of the things influencing quality of the FMEA is how to ensure that there are no misunderstandings in what is written down. This has been described as wording and

it does not appear that the case company has any defined way to ensure that misunderstandings do not happen besides ensuring everyone at the P-FMEA meeting agrees that everything written down is understood. Standardizing the way failure modes are described could help making more knowledge based decisions (Wirth et al., 1996), for example this could be achieved by using taxonomy systems, where you describe functions and subfunctions and what could go wrong for those specific subfunctions. This is exemplified in Figure 7.1.



**Figure 7.1:** Taxonomy system adapted from Wirth et al. (1996)

The system could also be a part in the Master-FMEA, where the definitions of the different functions and subfunctions are described in a separate EXCEL-sheet. The benefits of using this type of systems is that the P-FMEA team can check in the system how to describe the different functions and also find out what types of common causes this failure has. This could help the team to find causes that would not otherwise have been discovered. Another recommendation is therefore to have a system to **standardize the description of failures**.

## 7.9 Prioritization Workshop

These are the recommendations which were presented and evaluated in the prioritization workshop.

- Senior management support at all sites
- Define how P-FMEA should be prioritized or not be de-prioritized
- Define purpose
- Define time policies
- Define team policies
- Define updating P-FMEA policies
- Establish the connection to other tools and functions
- Establish a process to evaluate the P-FMEA
- Implement a training initiative
- Make use of lessons learned
- Establish change champions on all sites
- FMEA-report
- Make adaptations to fit the capabilities of the different sites
- Implement a facilitating role in their future P-FMEA meetings
- Standardize the description of failures

The results from the prioritization workshop can be seen in Figure 7.2 and they show that most of the recommendations were considered to have an impact on the organization. Only 2 out of the 16, were considered to be at the lower half of the impact scale. These two were: Make adaptations to fit the capabilities of the different sites, and the FMEA-report. The first one was considered by the group to not have a huge impact on the organization even through affecting individuals, hence it was regarded to be less impactful.

The rest of the recommendations were considered to be impactful and the majority of them were also considered to be easy to implement i.e. having high feasibility. Some recommendations, which were mostly connected to knowledge and evaluation, were considered difficult to implement. This is understandable since establishing these type of systems require a considerable amount of time and effort. A training initiative and an evaluating process are difficult to establish and would take time. But the reward might also be greater - many of the recommendations with lower feasibility were considered to be more impactful.

Eight of the recommendations were placed in the quick wins quadrant, where there is high feasibility and impact. These are easy to implement and will have big impact on

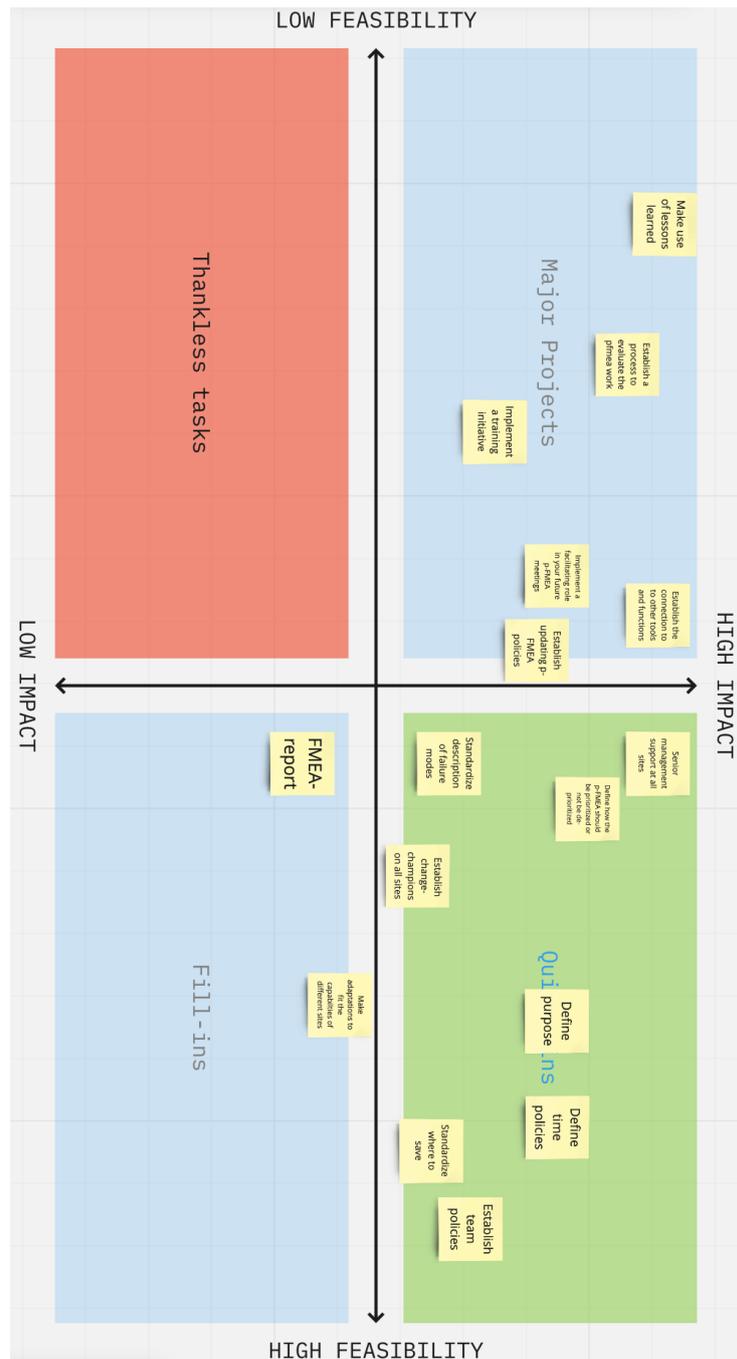


Figure 7.2: Result from Workshop

the organization. These are the ones the organization should focus on implementing first.

### 7.9.1 Analysis of Prioritization Workshop

During the workshop, the participants discussed the different recommendations in relation to each other. They mentioned that some of the recommendations are related and interdependent, for example that senior management support needs to

be established before the definition of how the P-FMEA should be prioritized can be made. They also placed post-it notes based on these relations - the position of the note representing the prioritization of the tool was decided partially based on the position of the note of senior management support.

Some of the recommendations that were placed in the quadrant of quick wins relate to recommendations that are less feasible. For example, defining the purpose and new policies for timing and teams can probably be done with ease, but spreading these policies might benefit from implementing the training initiative or utilizing change champions. Considering these interrelations, some factors might be more impactful than if they are considered alone. These types of analysis can be challenging to perform in a setting with limited time for discussion and explanations as the workshop was, and the participants might not have considered it for all recommendations.

Based on the prioritization workshop, the recommendations are proposed to be implemented at the case company in the order seen in Figure 7.3

*Senior management support* was considered one of the most impactful recommendations by the participants in the workshop and it has likewise been highlighted by previous researchers, as presented earlier. It is not as feasible as some of the other recommendations, but those that are more feasible are less impactful. Creating senior management support is also something that can be worked with in parallel with the more easy tasks, such as defining time and team policies. Therefore, the *defining of purpose, time and team policies* follows as quick wins to perform while the somewhat larger project of engaging senior management support is performed.

The *FMEA-report* was rated as the least impactful of all the recommendations. However, it became evident after the workshop that at least one participant saw it as a huge document that would only take time and energy without giving much in return. During the workshop, another participant stated that if it is correctly designed it can have an impact, but otherwise it will only be paperwork. In the analysis that lead to this recommendation it was described how the FMEA-report could be a tool to inform stakeholders, particularly senior management, of the main take aways from the P-FMEA. This was also something that had been described by several members of the organization. With this in mind, the recommendation to implement a FMEA-report is fifth on the list of recommendations. The thoughts and feedback from the participants still needs to be kept in mind however. It should be designed as a “one pager” or similar, and not be arduous to create. It should be tailored to inform of the major findings from the P-FMEA and fulfill what interviewee 3 (a person representing senior management) requested at the end of section section 6.4 - summarized in a holistic way. This can hopefully enable the creation of senior management support, since they through it can be informed and understand what the P-FMEA does for the organization, and what risks future products may have to live with.

1. Senior management support at all sites
2. Define purpose
3. Define time policies
4. Define team policies
5. FMEA-report
6. Define how P-FMEA should be prioritized or not be de-prioritized
7. Establish the connection to other tools and functions
8. Implement a facilitating role in their future P-FMEA meetings
9. Standardize where to save
10. Establish change champions on all sites
11. Implement a training initiative
12. Standardize the description of failures
13. Define updating P-FMEA policies
14. Establish a process to evaluate the P-FMEA
15. Make use of lessons learned
16. Make adaptations to fit the capabilities of the different sites

**Figure 7.3:** Priority order for the recommendations.

*Defining how to prioritize the P-FMEA* was considered impactful by the participants of the workshop, but they also pointed out that it is dependent on senior management support. The recommendation of *establishing the connection to other tools and functions* was seen as having similar impact as senior management support, but less feasible. When several of the quick wins have been performed, major projects with high impact can be prioritized.

*The implementation of the facilitating role* was seen as impactful, and the participants described that this could help create more unified P-FMEAs. It was also seen as a major but not huge project, and with this role, the participants thought that the knowledge of the rest of the team would be less important, since this person can be the expert.

There are a few quick wins that are less impactful than some of the major projects, but running them in parallel can help keep momentum up. This is since the quick wins can be achieved while working with a major project. Therefore, *standardize*

*where to save* is next on the list. It is not one of the most impactful but it was seen as the second most feasible so it should be straight forward to implement. *Establishing change champions* was not considered to have a major impact, but the research on implementation opine that these can help sustain a change. To implement and sustain the other recommendations, the establishing of change champions on all sites is tenth on the list.

To *implement a training initiative* was not seen as very impactful compared to other recommendations by the participants in the workshop, and its feasibility is in the lower region. The participants did as mentioned think that implementing a facilitator with great knowledge lessens the pressure of knowledge on the rest of the team. It is however still important that the participants have a holistic understand of the tool, the purpose and aim of P-FMEA and a training initiative can be helpful in spreading new guidelines and practices. In the light of this, to implement a training initiative is the next recommendation on the list.

The last recommendation in the quick win category is *standardizing the description of failure modes* and since it was the least impactful and feasible quick win it is the last of those on the recommendation list.

*The establishing of updating policies* was described as more work than you think by the participants and seen as a major project, resulting in it being further down on the list than for example defining team or time policies. It is followed by several major projects, where *establishing an evaluation process of the P-FMEA* is first. This was considered one of the most impactful but the next to least feasible. The participants of the workshop agreed that it would be helpful to know how well-accomplished the P-FMEAs are but that it is a challenging and large project to undertake. The company is therefore recommended to wait until many of the early wins are completed to be able to complete this recommendation.

*Make use of lessons learned* was the most impactful and least feasible of all the recommendations. The participants also thought that it would be easier to make use of lessons learned if the descriptions of failure modes have been standardized. Depending on how the evaluation of P-FMEAs is implemented, that output could help create lessons learned. The recommendation to make use of lessons learned is therefore after these two on the list.

Last on the list is the recommendation to *make adaptations to fit the capabilities of different sites*. The participants opined that the whole point of the project was to create a global standard and that this could contradict that purpose. One participant did mention that it could have an impact if it ensured usage of the tool at all sites. In the validation process of the research results, it was mentioned that not all sites have the same experts in all fields as others have, so it can still be meaningful to keep this recommendation in mind - sites do not have the same capabilities and the global standard should take that into account.

# 8

## Discussion

The purpose of this thesis is to understand what critical success factors there are when implementing a global FMEA standard. Even though there is much research on implementation of quality tools and practices, implementation of FMEA is less explored. This thesis has tried to fill this gap by examining critical success factors for implementation of quality tools and practices, as well as what researchers have highlighted as important for the success of FMEA. The identified factors can be found in left part of Figure 8.1. These factors have then been compared with a case company using P-FMEA to establish both if the factors identified from previous research on quality tools match what organizations implementing and using FMEA faces, and if there are other factors that are more vital to these organizations.

Interviews with practitioners and managers involved with P-FMEA have been used to establish what factors matter for the case company, and these interviews have been analyzed based on the framework in Figure 8.1. The analysis resulted in a number of recommendations for the company implementing P-FMEA, and these can be seen in the right part of the Figure 8.1

The framework lists a number of factors that impact the success of implementing FMEA. Management commitment, understanding, and involvement has been brought up by many researchers as vital for the success of quality tool implementations (Bunney & Dale, 1997; Dale et al., 1997; Netland, 2016). Leadership support and, at some sites, involvement, was brought up by many interviewees as lacking and as something that could improve their performance. Since it has been demonstrated to be central in both the literature and in the empirical findings, leadership seems to need extra attention when it comes to implementing FMEA.

The higher degree of complexity given by the new AIAG-VDA format puts a higher demand for leadership. If the tool becomes more resource-demanding due to the new format it must be prioritized by senior management. Employee attitude and motivation could be affected by a higher degree of leadership motivation and commitment and this could become more important if the new format demands more time and effort.

<b>Implementing FMEA</b>		
<b>Area</b>	<b>Success factors</b>	<b>Recommendations for Case Company</b>
<b>Leadership</b>	Commitment, involvement and support	Senior management support at all sites
		Define how P-FMEA should be prioritized or not be de-prioritized
	Strategy, vision and purpose	Define purpose
<b>Organizational</b>	Policies and structures	Define time policies
		Define team policies
		Define updating P-FMEA policies
	Resources and collateral implementation	Establish the connection to other tools and functions
	Viability	Establish a process to evaluate the P-FMEA
<b>Knowledge</b>	Training and competence	Implement a training initiative
	Continuous improvement	Make use of lessons learned
<b>Individual</b>	Employee commitment and motivation	Define purpose
		Implement a training initiative
	Influence of company culture	Implement a training initiative
<b>Processual</b>	Planning, timing and pacing	Prioritization workshop
	Change champion	Establish change champions on all sites
<b>Stakeholder management</b>		FMEA-report
<b>Contextual</b>	Contextualized tools and methods	Make adaptations to fit the capabilities of the different sites.
	Context and fit	
<b>Effective FMEA Practice</b>		Implement a facilitating role in their future P-FMEA meetings
		Standardize the description of failures.
		Standardize where to save

**Figure 8.1:** Framework applied on case company.

The area of organizational factors include three different factors (Policies and structures, Resources and collateral implementation, Viability), all of which originated from the literature (cf. (Coronado & Antony, 2002; Dale et al., 1997; Done et al., 2011)). Lack of policies regarding for example team and time has resulted in problems for the case company and many of the recommendations aim to solve these. The importance of how the P-FMEA is connected to other tools is highlighted in the literature (Teng & Ho, 1996) and this is also central since it impacts collateral changes (Venkateswarlu & Nilakant, 2005). This was lacking at the case company and therefore should be kept in mind in future implementations of FMEA. Viability become less focused on the financial value since costs are not a part of the FMEA so it will instead include the aspect of evaluating the ongoing FMEA in order to improve the tool. Therefore Viability refers to knowing what you do and how you

could to it better, how can we evaluate this? Is it viable to continue using the tool? This is something not discussed to a great extent in the literature, some sources mentions the importance of measuring (Bunney & Dale, 1997) but it is mostly an area that is unexplored in previous research.

The organizational area will also become more important with the new AIAG-VDA format since the more complex format puts an further emphasis on structure and guidelines to run smoothly, more steps in the process requires more structure and policies. It is also crucial that the FMEA work is given needed resources as the complexity from new AIAG-VDA format will increase. The global aspect puts even more emphasis on this, each site must be given the resource they need to conduct the analysis and different sites might have different needs. A more resource-demanding process could also increase the need for evaluating the use of the tool.

The most often mentioned success factors from research on implementing FMEA concerns knowledge (cf. (Estorilio & Posso, 2010; Dale et al., 1997; Teng et al., 2006)). At the case company, knowledge has been highlighted as impacting the overall performance of P-FMEAs and a lack of knowledge has resulted in trouble with finding the right level of detail, the connection to other tools, and the understanding of why the method is used. It also results in varying P-FMEAs since there is no baseline method that all teams could follow. Knowledge about the tool should therefore be a top priority for companies implementing FMEA.

Knowledge is also an area which is affected by the AIAG-VDA guidelines since the increase of complexity is remedied by an improved understanding on why the the FMEA requires more steps. Competence will decrease the risk for lack of the right attitude and motivation, so in order to ease the transition to the AIAG-VDA format, companies need to educate their employees in this.

The area related to the individual has in a similar manner as leadership and knowledge been highlighted as an important aspect for implementing FMEA, both in terms what the literature states (Buchanan et al., 2005) and what was found at the case company. Employee commitment was partly found in the organization but it seemed to vary a good deal, and this was regarded as an issue by the employees. Commitment and motivation seem to be a crucial factor for any type of change according to the literature, it should therefore be taken into consideration when implementing FMEAs.

Motivation and attitude of employees is important when implementing any FMEAs and it is not increased by the new AIAG-VDA format. It will be an important area regardless of what format of FMEA the company chooses. Transitioning from one format to the AIAG-VDA format could increase the need for the employees to understand why they are doing what they do but it should not increase the importance of the work companies do with attitude and motivation.

Processual issues were not something identified at the case company and since this thesis does not include the complete implementation, it is difficult to draw any specific conclusions from it. However, the consequence of not planning and making sure someone is responsible for the change has been described to cause issues (Buchanan et al., 2005; Done et al., 2011) for the implementation and should therefore not be ignored.

The political area focused on stakeholder management, having the stakeholders connected and involved in the process is expressed vital for the sustainability of implementation. This is to allow for a constructive and open dialogue regarding the needs and expectations of the different stakeholder groups (Done et al., 2011). The case company did not have much focus on this factor, but it influenced them since many of the interviewees expressed the need for senior management to be more involved. Therefore, companies implementing FMEA should evaluate how they are and should involve stakeholders like senior management, since it is both important and was found to be lacking at the case company.

The importance of stakeholder management is not affected by the new AIAG-VDA format. The format discusses the aspect of involving stakeholders, which is maybe more than other formats do, but in general, stakeholder management is equally important in this format as in any other and it should not be affected by a change in format.

The contextual area was expressed as another important aspect of implementation (Sousa & Voss, 2008), but it was not considered in specific at the case company. The overall idea of creating a contextualized global standard is good but the differences in culture and capabilities between the sites indicate that local adaptations should be implemented. The tool and the new AIAG-VDA handbook form a BP for the case company, but this does not mean any company should just copy and paste it.

The contextual area's centrality will become more important due to the increased complexity and resource need of using the new AIAG-VDA format. This could become challenging for companies, but having contextualized the tool could aid in reducing the workload of the process. This therefore makes the contextual area more important in this format. Companies should try to adapt the tool to fit their capabilities in order to reduce the complexity. The global aspect increases the need to have room for interpretation on different sites, some sites might not have the capability for certain procedure so having the opportunity to adapt it toward your needs could be the solution.

The last area which was also the last one introduced is the Effective FMEA Practice area. Many researchers have emphasized factors such as scoring, group constellation and timing of the FMEA (Aldridge et al., 1991; Dale & Shaw, 1990; Teng et al., 2006) to promote the success of the FMEA. Many of the issues expressed from the

P-FMEA team connected to these types of problems, and most of these factors lacked clear guidelines. A focus on deciding these things when implementing FMEA does therefore seem appropriate.

Some factors will be less important to focus on with the new format. For example, many of the scoring issues will be taken care of by the new AP system, such as counting backwards. Thus, the new AIAG-VDA format may implicate that less focus should be given to this area.

## 8.1 Limitations and Future research

This study has been based on an explorative single case study and the purpose was to broaden the understanding of what critical success factors there are when implementing FMEA at a global company. The empirical findings have strengthened the understanding of otherwise mainly theoretically derived success factors. However, the testing of the factors in an actual implementation goes beyond the scope of the research. Therefore, a future study of these factors during and after an implementation would help strengthen or disprove their criticality. Furthermore, the case company studied is a manufacturing company designing and producing products partly to the automotive industry. Future research could include a similar study in a non-automotive company to see if similar factors impact implementation of FMEA in other industries. Moreover, since the research has a single case setting, it would be of interest to test these factors in several different organizations to see what factors are highlighted in many organizations and how it differs from the factors derived from this study. Lastly, the new AIAG-VDA guidelines had not been implemented at the time of this study, so their effects could not be studied. At the time, the handbook was new which meant that very few companies had implemented it so it could not be studied elsewhere either. Even if that was possible, any company that had implemented the new format, the implementation would have been in the early stages and it would therefore not have been possible to study any long term effects. Future research should therefore explore the effects of the new handbook after some time usage.



# 9

## Conclusion

In this chapter, the conclusions from the research are presented. This is done by answering the research questions.

***RQ1. What critical success factors are there when implementing an FMEA?***

A number of factors have been identified as critical success factors when implementing FMEA.

*Leadership* includes setting vision and purpose as well as giving support to those using FMEA. *Organizational* factors covered things such as policies, resources, collateral changes and viability. *Knowledge* was one of the most frequently mentioned critical success factor among the literature and seen as important in the empirical findings. In an implementation of FMEA this area involves training the people performing FMEA and reusing knowledge from one FMEA to another.

The *Individual* success factors are connected to motivation and commitment with the employees while *Processual* concerns how the actual change happens, connecting to the timing and pacing of events as well as the importance of change champions. *Stakeholder Management* was a political factor that seem to influence the implementation of FMEA and the area of *Contextual* involves contextualization of tools and methods as well as how the tool fits the context. Lastly, *Effective FMEA practice* involves using the tool in an effective way.

***RQ2. What critical success factors are there when implementing a standardized P-FMEA according to the first edition AIAG-VDA standard in a global manufacturing company?***

The different areas in the framework have been discussed in previous chapters with perspectives regarding the global and new AIAG-VDA guideline. *Leadership*, *Organizational* and *Contextual* are the areas which will become more important with the new AIAG-VDA format. The higher degree of complexity forces the organization

## 9. Conclusion

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to invest more in leadership commitment and resources. Due to this format being a part of future customer requirements, a company implementing it cannot cut corners. The FMEA has to be prioritized and given the time and resources it needs to be conducted properly. It will require more, so a company implementing the new format should also focus on trying to reduce the complexity. The organization will therefore benefit on focusing on contextualizing the tool to decrease the complexity.

The new AIAG-VDA format should not affect the other areas in the framework except one, *Effective FMEA practice*. This area will need less attention in the new format since many of the problems that could arise in this area will be dealt with, mainly the issues with scoring.

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# A

## Appendix A

The following questions were used as a base for the interviews with interviewees from **Quality Department, Production Engineering** and the **Project Management**:

1. Could you please tell us about yourself and your role in the company? How long have you worked at the case company with this role?
2. Could you please tell us about your part in a regular P-FMEA, from start to finish?
3. How have you acquired your knowledge and training of P-FMEA? Follow up - Formal education/just through meetings etc. Do you feel that you have enough knowledge to perform your role in P-FMEA?
4. Please tell us what you consider to be the purpose of P-FMEA
5. If it was not an external requirement - do you think the case company should perform P-FMEA? Follow up - specifically AIAG-VDA P-FMEA?
6. Why does the case company perform P-FMEAs? What value are you aiming to get from it?
7. Could you please tell us how you think P-FMEA relates to other ways of working at the case company?
8. Could you please describe an example when you think a P-FMEA has worked very well?
9. Could you please describe an example when you think a P-FMEA has not worked well?
10. In your opinion, what factors are most important in succeeding with a P-FMEA?
11. What knowledge is needed to perform a P-FMEA? (As an individual)

12. How do you spread the knowledge of P-FMEA through the company?
13. Could you please describe how you at the case company make use of the knowledge generated during the P-FMEA processes?
14. Could you please tell us what resources are needed to perform a P-FMEA, and how decisions are made regarding cost and resource usage?
15. How do you determine if a P-FMEA is successful?
16. Could you please tell us how the responsibility of the P-FMEA looks throughout the process today and in an ideal scenario?
17. Could you please tell us about the role of senior management in P-FMEA and how their role would look in an ideal scenario?
18. How, in your opinion, is P-FMEA work valued at the case company? Do you get any recognition for your work with P-FMEA? (Maybe relating to your career, gratifications etc)
19. How does senior management communicate regarding P-FMEA today and how would they communicate in an ideal scenario?
20. Could you please tell us about the timeframe for performing a P-FMEA and your opinion about it?
21. Could you please tell us how you think P-FMEA fits your ways of working? Follow Up - Please tell us how it's adapted?
22. Could you tell us of any obstacles to your work with P-FMEA? Follow up - Anything that might hinder the completion/ make the completion of P-FMEA difficult?
23. How long and how many meetings are usually held when performing a P-FMEA?
24. Could you please describe how the scoring process of a P-FMEA usually works?
25. How does the group that conducts a P-FMEA look? Who takes part when?
26. What role does historical data play in P-FMEA?
27. Could you please describe how it works with updating the P-FMEA? After it's done that is.
28. How do you ensure that there is no room for misunderstandings when it comes to what is written down in a P-FMEA?
29. Please tell us who has an interest in the P-FMEA work and how are those

interests monitored?

30. Which type of company culture do you think is needed to be successful with a P-FMEAs?
31. What do you think of P-FMEA more generally? As a tool and as a way of working?
32. Do you think your view is shared by the rest of the company? Why?
33. What question do you think we should have asked you that we have not done?
34. Do you have any other thoughts you want to share?
35. Is it okay if we contact you by email if we have any further questions?

**Senior management** were asked the following questions:

1. Could you please tell us about yourself and your role in the company? How long have you worked at the case company with this role?
2. Could you please tell us about your part in a regular P-FMEA, from start to finish?
3. How have you acquired your knowledge and training of P-FMEA? Follow up - Formal education/just through meetings etc. Do you feel that you have enough knowledge to perform your role in P-FMEA?
4. Please tell us what you consider to be the purpose of P-FMEA
5. Why does the case company perform P-FMEAs? What value are you aiming to get from it?
6. Could you please describe an example when you think a P-FMEA has worked very well?
7. Could you please describe an example when you think a P-FMEA has not worked well?
8. Can you tell us how you in senior management have seen P-FMEA as a tool from when you became involved in it for the first time at the case company until today?
9. Can you tell us in which situations the senior management discusses P-FMEA?
10. When do you in the management find out more detailed problems that have arisen in a P-FMEA?
11. Can you tell us how you have reasoned about the issue of liability regarding

P-FMEA?

12. Can you tell us your view about what control senior management should have to ensure that a P-FMEA is carried out in a desirable way?
13. How do you spread the knowledge of P-FMEA through the company?
14. Could you please tell us what resources are needed to perform a P-FMEA, and how decisions are made regarding cost and resource usage?
15. How do you determine if a P-FMEA is successful?
16. Could you please tell us how the responsibility of the P-FMEA looks throughout the process today and in an ideal scenario?
17. Could you please tell us about the role of senior management in P-FMEA and how their role would look in an ideal scenario?
18. How, in your opinion, is P-FMEA work valued at the case company? Do you get any recognition for your work with P-FMEA? (Maybe relating to your career, gratifications etc)
19. How does senior management communicate regarding P-FMEA today and how would they communicate in an ideal scenario?
20. Could you please tell us about the timeframe for performing a P-FMEA and your opinion about it?
21. Could you please tell us how you think P-FMEA fits your ways of working? Follow Up - Please tell us how it's adapted?
22. Please tell us who has an interest in the P-FMEA work and how are those interests monitored?
23. Which type of company culture do you think is needed to be successful with a P-FMEAs?
24. What do you think of P-FMEA more generally? As a tool and as a way of working?
25. Do you think your view is shared by the rest of the company? Why?
26. What question do you think we should have asked you that we have not done?
27. Do you have any other thoughts you want to share?
28. Is it okay if we contact you by email if we have any further questions?

The **Design Department** were asked the following questions:

1. Could you please tell us about yourself and your role in the company? How long have you worked at the case company with this role?
2. Could you please tell us about your part in a regular P-FMEA, from start to finish?
3. How have you acquired your knowledge and training of P-FMEA? Follow up - Formal education/just through meetings etc. Do you feel that you have enough knowledge to perform your role in P-FMEA?
4. Please tell us what you consider to be the purpose of P-FMEA
5. If it was not an external requirement - do you think the case company should perform FMEA? Follow up - specifically AIAG-VDA FMEA?
6. Could you please tell us about your part in a regular D-FMEA, from start to finish?
7. Could you tell us about your experiences with P-FMEA?
8. Why does the case company perform P-FMEAs? What value are you aiming to get from it?
9. Why does the case company perform D-FMEAs?
10. Could you please tell us how you think D-FMEA relates to other ways of working at the case company?
11. Can you describe how D-FMEA and P-FMEA are connected at the case company?
12. How do you think the cooperation between D- and P-FMEA should work?
13. How does the information transfer between D- and P-FMEA look?
14. Could you describe the roles of Production Engineering and the Quality Department when you perform D-FMEA? follow up - Could you give an example of when you think it has worked well, Could you give an example of when you think it has worked poorly
15. Could you describe how you at Design are involved in the P-FMEA work? Follow up - Could you give an example of when you think it has worked well? Could you give an example of when you think it has worked poorly?
16. Can you tell us about the structure around the start-up of a P-FMEA, what must you have done at Design before it is possible to start P-FMEA?

17. Could you please tell us what resources are needed to perform a D-FMEA, and how decisions are made regarding cost and resource usage?
18. How do you determine if a D-FMEA is successful?
19. Could you tell us of any obstacles to your work with D-FMEA? Follow up - Anything that might hinder the completion/ make the completion of D-FMEA difficult?
20. Could you please describe how the scoring process of a D-FMEA usually works?
21. How does the group that conducts a D-FMEA look? Who takes part when?
22. What role does historical data play in D-FMEA?
23. Could you please describe how it works with updating the D-FMEA? After it's done that is.
24. How do you ensure that there is no room for misunderstandings when it comes to what is written down in a D-FMEA?
25. Could you please tell us how you think D-FMEA fits your ways of working? Follow Up - Please tell us how it's adapted?
26. Do you at Design have an interest in a P-FMEA being performed and how do you monitor that?
27. Which type of company culture do you think is needed to be successful with a FMEAs?
28. What do you think of FMEA more generally? As a tool and as a way of working?
29. Do you think your view is shared by the rest of the company? Why?
30. What question do you think we should have asked you that we have not done?
31. Do you have any other thoughts you want to share?
32. Is it okay if we contact you by email if we have any further questions?

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