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Production Part Approval Process Evaluation

A Case Study at a Large OEM

Master's Thesis in the Master Programme
Quality and Operations Management

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Abstract

For large Original Equipment Manufacturers (OEMs) to manufacture products and parts in an efficient manner, good collaboration with suppliers is crucial. To facilitate efficient supplier collaboration, the Automotive Industry Action Group (AIAG) developed the Production Part Approval Process (PPAP) to make sure that supplier could deliver high quality parts to automotive OEMs. This process is used all over the world and a large OEM in Sweden has used it for many years. The OEM had recently experienced issues with delays and increasing costs when developing new products and identified the PPAP as a potential improvement area. Therefore, the purpose of this thesis was to evaluate the PPAP at the OEM to identify challenges within the process and to give recommendations for the OEM to mitigate these challenges.

To manage this, the research was designed as a case study to achieve a high-level of focus on the OEM and the Supplier Quality Department working with the PPAP. The empirical data was gathered through semi-structured interviews and complementary observations. The data was then systematically analysed to identify the underlying themes of challenges that mostly affected the OEM.

The identified themes of challenges that were deemed the drivers for the issues faced at the OEM were, *Knowledge Sharing, External & internal communication, Collaboration between stakeholders* and *High administrative workload.* To mitigate these challenges, the authors suggest that the OEM should start focusing on two areas in the short and medium term. Firstly, the OEM should focus on increasing knowledge sharing within the organisation and with the suppliers by initiating education sessions and using existing web systems for that purpose. Secondly, the OEM should focus on investigating the supplier perspective of the PPAP as a first step to implementing a new IT system for the PPAP and Advanced Product Quality Plan (APQP). This should be followed by an investigation into the demands and requirements on an IT system for all stakeholders connected to the PPAP at the OEM.

Keywords: Production Part Approval Process, PPAP, Process Evaluation, Process Improvement, OEM, Knowledge sharing, Collaboration, Communication, Supplier collaboration

Terminology & Abbreviations

SQE – Supplier Quality Engineer

SQD – Supplier Quality Department

AIAG – Automotive Industry Action Group

APQP – Advanced Product Quality Plan

PPAP – Production Part Approval Process

PPAP approval – When the component design and its technical documentation is, submitted, checked, and signed by an SQE. An approval means that the component and the processes used to produce it, is ready for serial production

OEM – Original Equipment Manufacturer

R&D – Research & Development

RTS – Review of Technical Specification

PD – Product Developer, an OEM employee working with developing products

Buyer – Employee at the OEM that is responsible for purchasing parts

BPM – Business Process Management

RFQ – Request for Quotation

Developing supplier – Supplier which develops and produces components for the OEM. Development is outsourced

Producing supplier – Supplier which only produces components for the OEM. Development is conducted in-house.

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1. Introduction

The following chapter will start with explaining the background of the thesis. The following section outlines the purpose & aim which shows the reader what the thesis aims to fulfil. This is followed by a set of delimitations to scope the thesis. After this, the three research questions are presented and explained, which forms the basis of the conducted research.

1.1 Background

Original Equipment Manufacturers (OEMs) do not have always have the capabilities or knowledge to develop new products through innovation. Therefore, these firms often seek knowledge externally from suppliers and secure these capabilities by outsourcing R&D activities to them (Un & Rodríguez, 2018). McIvor, Humphreys & Cadden (2006) explains that supplier involvement in product development, where R&D activities have been outsourced, frees up resources and enables firms to focus more on their core competencies. The authors also explain that supplier involvement reduces the complexity of development projects that are being conducted internally. To succeed with supplier involvement, the authors further elaborate that effective and efficient collaboration is needed.

With today's rapid change in technologies, increased diversity among products, and shorter product life cycles, OEMs need to closely collaborate with suppliers to assure and improve product quality (Li, 2012). For this collaboration to work, these suppliers provide the OEMs with either development or manufacturing services according to component requirements and specifications. This creates a major need for transferring knowledge, information and data between the buying organisation and the supplier (Li, 2012). Furthermore, it also puts high demands on the buying organisation's ability to communicate internally and work in an efficient and effective way. An organisation lacking these prerequisites, can face challenges in relationships with suppliers which are crucial for the success of their business (Li, 2012). Van Echtelt, Wynstra, Van Weele, & Duysters (2008) points out, that a good buyer-supplier relationship needs activities that exhibit high degrees of cross-functional involvement from R&D, purchasing and manufacturing. This involvement was aligned with the fact that communication is important between the departments and the suppliers (Van Echtelt, Wynstra, Van Weele, & Duysters, 2008).

For OEMs to be able to collaborate and communicate efficiently with suppliers, an initiative was taken 1982 by the Automotive Industry Action Group (AIAG) to form standardised process guidelines for automotive OEMs working with suppliers. Moreover, this initiative was taken to provide OEMs, suppliers and service providers with procedures to drive down project complexity and cost but also to enhance product quality to the end customer (AIAG, 2019).

A large OEM in Sweden is dependent on being able to cooperate with a widespread global network of suppliers in product development. Together they strive to deliver desired high-quality products to the customers. The OEM has more than 50 000 suppliers globally, developing and delivering components to their plants (Personal Communication, September 20, 2019). Hence, this requires major efforts in building long-lasting relationships, communication networks, and trust with their suppliers to create value for both sides. In addition to this, a large amount of information and knowledge is sent between the organisation, suppliers, and within the organisation. This creates requirements on both ends to work according to set standards that enable the organisation to work effectively and efficiently towards common objectives. In a big organisation, such as the OEM, the main objective is to deliver a desired product to the end customer. To achieve this, the

OEM needs to work cross-functionally and in close collaboration with suppliers (Personal Communication, September 20, 2019).

The OEM is divided into three major divisions, where purchasing has the most contact with suppliers. The purchasing department is responsible for the procurement of components that are used for building the OEM's products, including aftermarket, for all brands belonging to the OEM. Within the purchasing department, the Supplier Quality Department (SQD) is responsible for all quality related communication with the supplier. This includes audits, follow-ups, and all activities related to product quality that suppliers are performing to aid product development. Within SQD, the Supplier Quality Engineers (SQE) works according to a set of supplier quality process guidelines created by the AIAG. These guidelines are called Production Part Approval Process (PPAP) and Advanced Product Quality Planning (APQP).

Within SQD, it is vital to follow processes that enables effective and efficient collaboration, internally and with suppliers. In the current state, the SQEs faces problems in the collaboration with the suppliers even though they work according to standardised processes. Moreover, the challenges that they face in their collaboration with their suppliers can be tracked to their way of working in the process called PPAP. Today, the process does not enable the SQEs to collaborate with the suppliers in a consistent way, where the quality outcome from product development varies. In return, this can lead to increased development costs and delays for the OEM.

1.2 Purpose & Aim

For large automotive OEMs to efficiently collaborate with thousands of suppliers and bring new products to market, clear standards and guidelines are needed as explained above in the background. One of the most used guidelines in the automotive industry is, as described in 1.1 Background, AIAG's PPAP. This guideline has been developed to facilitate efficient collaboration between suppliers and OEMs to deliver high quality parts and products. At a large OEM, the SQEs are experiencing challenges when working with PPAP which result in quality issues, delays, and friction within the organisation.

Given this, the purpose of this thesis was to first, investigate how SQEs work at a large OEM with PPAP to identify the most pressing challenges they face in the current state. Secondly, to evaluate the identified challenges within and in connection to the process and give recommendations to the OEM that could increase performance. By doing this, the aim of the thesis was to give the OEM the tools needed to improve the PPAP and in the end increase overall quality in the organisation.

1.3 Delimitations

The purpose of this thesis was to provide an OEM with a current state analysis focusing on the purchasing department, and especially the SQD. Therefore, the authors did not collect data from other departments, such as manufacturing and product development. Furthermore, the aim of the analysis was to evaluate the current way of working with PPAP which excludes all other process if they are not directly connected to PPAP.

This thesis was, as mentioned earlier, focused on evaluating the current state of the PPAP at the OEM. It will therefore not result in fully formed and directly implementable suggestions due to time limitations. The recommendations given aims to guide the OEM by showing them actions that can be taken and areas for further research with the goal of mitigating the identified challenges with the current state.

1.4 Research Questions

To fulfil the purpose of this thesis, the authors needed to understand the way of working with PPAP at the SQD. This will enable the authors to conduct an as-is analysis and therefore, the first research question is defined as:

RQ1

How do the SQEs work interdepartmentally and with their suppliers in order to approve a PPAP?

When the first research question has been answered, the data gained will provide the authors with information containing the key challenges the SQEs face in their day to day work. This leads to leads us to the second research question:

RQ2

What challenges are the SQEs facing when working towards a PPAP approval in collaboration with suppliers and interdepartmentally?

When potential challenges have been identified, the authors will need to build a thorough understanding of process management, process improvement, and organisational development theory. This will give the authors the necessary tools to analyse the identified challenges and give recommendations on what the OEM can do to mitigate them. The third research question is therefore formulated as follows:

RQ3

What recommendations should be considered in order to mitigate the key challenges currently faced in connection to PPAP?

When the above described questions have been answered, the purpose of the thesis will be fulfilled. The result of the thesis will provide the OEM with a detailed description of the current way of working with PPAP. Furthermore, the identified challenges connected to this work will be outlined and analysed. Finally, the conclusions from the thesis will aim to provide recommendations to mitigate identified challenges within the process.

2. Theoretical Framework

In this chapter, the theoretical framework for the thesis is presented to give the reader a good understanding of the underlying topics and themes. First, Business Process Management and Process Improvement is described, which is followed by Change Management. Thirdly, Knowledge Management is outlined containing Knowledge Transfer and Communication. Lastly, Supplier Quality Processes, namely PPAP and APQP, are further explained.

2.1 Business Process Management

Business process management (BPM) is, according to Dumas, La Rosa, Mendling, & Reijers (2013), the discipline of studying, codifying and improving how work is performed in an organisation. Its main purpose is to ensure that an organisation can work in a systematic way to deliver consistent results and find ways to improve their operations outcomes (Dumas, La Rosa, Mendling, & Reijers, 2013). Dewey (2019) adds to this and describes it as a method that enables organisations to evaluate workflows by using BPM as a template for grasping the big picture of the network of operations.

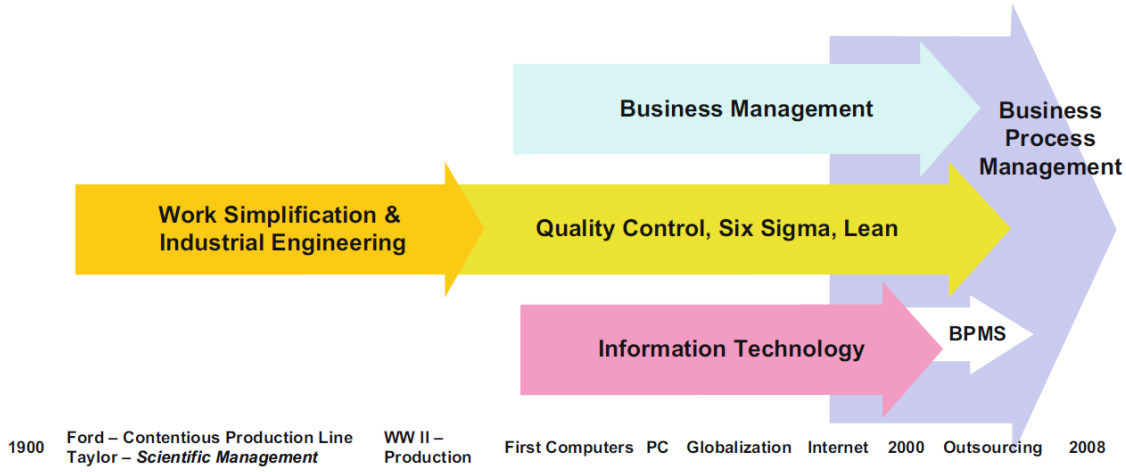

Figure 1 The evolution of Business Process Management, from Harmon (2015)

The development of business process management comes from the early days of the Ford era where focus was on work simplification of tasks and industrial engineering (Harmon, 2015). This later developed into practices and areas such as, Business Management, Lean and Information Technology which BPM can be seen as a combination of (Harmon, 2015). This is illustrated in Figure 1 below. BPM can, to summarise, be seen as an extension of previous theories, tools, and methods used in other fields (Glykas, 2013; Vom Brocke & Rosemann, 2015).

According to Dewey (2019), BPM was developed from previous views that an organisation is set of disconnected process. When this was the case, the individual process was evaluated and improved often without taking the larger picture§ into account. This created issues since the individual processes are interconnected and work together as a whole (Dewey, 2019). Organisational research has later shown that a more holistic view is needed to create an organisation that works well as a whole (Hammer, 2015). This is a reason for BPMs emergence as

a way of seeing the entire effort of bringing a product or service to a customer as a set of interconnected processes (Dumas, La Rosa, Mendling, & Reijers, 2013). For organisations to successfully work with BPM, there are several success factors to take into consideration. These factors include, strategic alignment, top management support, communication, and interdepartmental cooperation (Vukšić, Brkić, & Tomičić-Pupek, 2018). The authors continue to argue that these success factors can be connected to processes being everywhere in an organisation and to succeed, one needs a have holistic view on them in the entire organisation. Dewey (2019) continues to point out that another factor important for success is to manage processes continuously to increase value for the end customer.

Process management can be described as a continuous cycle according to Hammer (2015). This cycle is a way of viewing the understanding and development of a process and its evolution when gaps are found. The process, which is depicted in Figure 2, starts with the formal design and implementation of a process, which is then monitored to ensure that it is followed by the organisation. Processes that are creative and of low volume is usually more inclined to have large variation and individual initiatives. This is a major source of unreliability and is unsustainable in the long-term. Hammer (2015) continues to make the point that the process needs to be managed on an ongoing basis and clear measurements of performance should be developed and compared with customer needs. It is at this stage that deviations from the set performance can be identified and fixed.

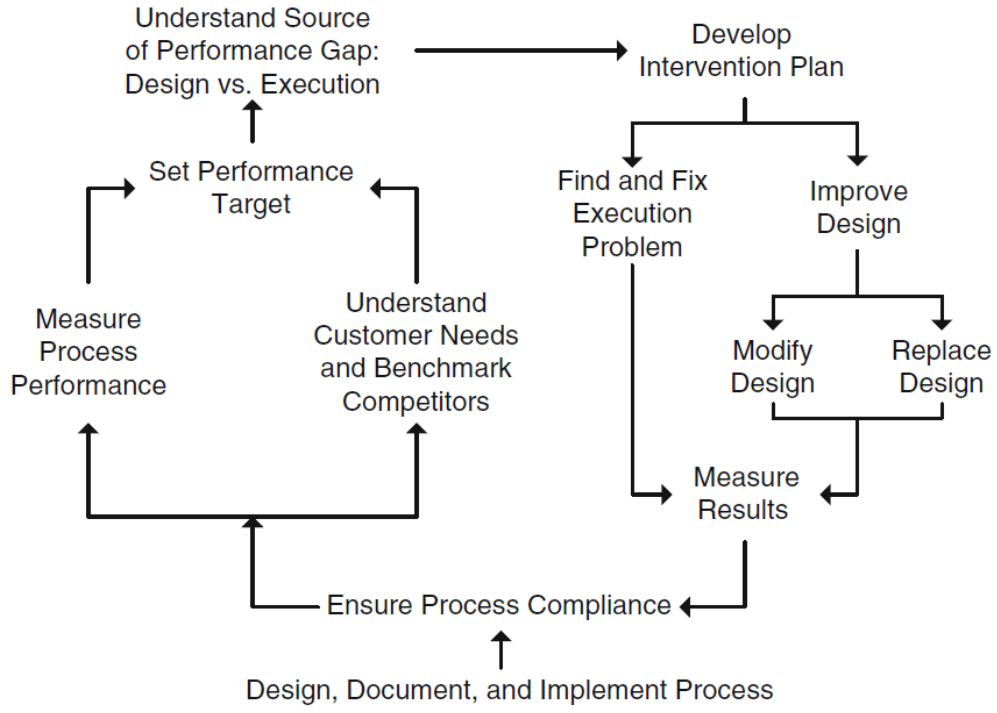

Figure 2 Process Management Cycle, from Hammer (2015)

According to Hammer (2015), there are two main sources of issues in a process, *design,* or *execution* issues. The identification of which can be done by examining the type of performance issues the organisation faces. If the issues occur often, they are most likely of a design nature, and if they come seldom, it is probably due to the execution. This is an important distinction to make because the nature of the problem dictates how it should be approached. If a problem occurs frequently, and is deemed to be a design fault, then it is usually easy to find but hard to fix. The

opposite is true for problems that have to do with execution. They are harder to find due to the need for a root cause analysis but when they are found, they are easy to correct. As an example, when trying to solve a design fault, the entire process usually needs to be redesigned for the issue to be mitigated. When trying to mitigate process deficiencies, being either design or execution based, the role of information technology needs to be addressed.

Solutions based on software have had a great impact on BPM especially in the sense of measuring and monitoring of processes (Vom Brocke & Rosemann, 2015). These systems help employees by giving them a direct understanding of the existing process (Vom Brocke & Rosemann, 2015). However, Dewey (2019) argues that BPM is often mistaken as introducing things like software to speed up productivity or enable efficient documentation handling. Software is an important part of BPM since it can enable these things but should not be seen as a substitute for it (Dewey, 2019). The importance of software in BPM is further strengthened by Vukšić, Brkić, & Tomičić-Pupek (2018) who state that implementing BPM software is a good tool to enabling successful BPM. When implementing an IT system to manage a process it is crucial to take into consideration the fit between the process characteristics and the capabilities of the IT system (Tirkman, 2010). The author continues to state that if an IT system is going to be used it needs to match the specific activities of the worker, otherwise the system will not be adopted. This can also be said for organisations as a whole that in order for a company to experience increased performance from implementing an IT system it needs to match the business processes of the organisation (Tirkman, 2010).

2.1.1 Process Improvement

Process improvement can be described as a systematic approach to realign critical organisational processes to achieve increased performance (King, King, & Davis, 2014). These actions are often taken to, either increase the value for the end customer directly, or to improve the working situation for the employees (Andersen, 2007). When improving processes there are a variety of improvement types, which are characterised by the amount of work and the envisioned end result. Eileen & Scott (1995) describes two types of improvements, process improvement and process reengineering. Process improvement is when an existing process is used as a basis for incremental improvements. The authors describe it as an evolution of the current way of doing business. Reengineering on the other hand is when revaluation of the entire process is conducted, and it aims for widespread radical change as. This is described as a revolution of to the current way of doing business (Eileen & Scott, 1995). This categorization is somewhat supported by Holweg, Davies, & Meyer (2018) who describe process improvement with lean methodology in mind. The authors agree that there are two types of improvements, but their view is that there are continuous improvements, or Kaizen, and radical improvements, Kaikaku. What differs between the two views most is that Holweg, Davies & Meyer (2018) state that continuous improvements form the basis of radical improvements whist Eileen & Scott (1995) mean that the two forms of improvement are more separated. However, both authors agree that process improvement, in all forms, is needed for companies to deliver value to their customers.

Process improvement is something that is necessary for all companies who want to stay competitive and keep high standards (Holweg, Davies, & Meyer, 2018; Andersen, 2007; Eileen & Scott, 1995; King, King, & Davis, 2014). This is due to the fact that processes deteriorate over time because workarounds and non-standard activities slowly start to appear if the process is left to itself (Holweg, Davies, & Meyer, 2018). This leads to increases in variation and complexity which in turn decreases performance over time (Holweg, Davies, & Meyer, 2018; Andersen, 2007). Andersen (2007) writes that to mitigate performance decline, a company needs to have a plan for maintaining processes to stop them from deteriorating. It is also important for organisations to

put real effort into increasing performance to stay competitive. In Figure 3 below it is shown that performance of a process will decrease over time if no actions are take which further highlights the importance of process improvements.

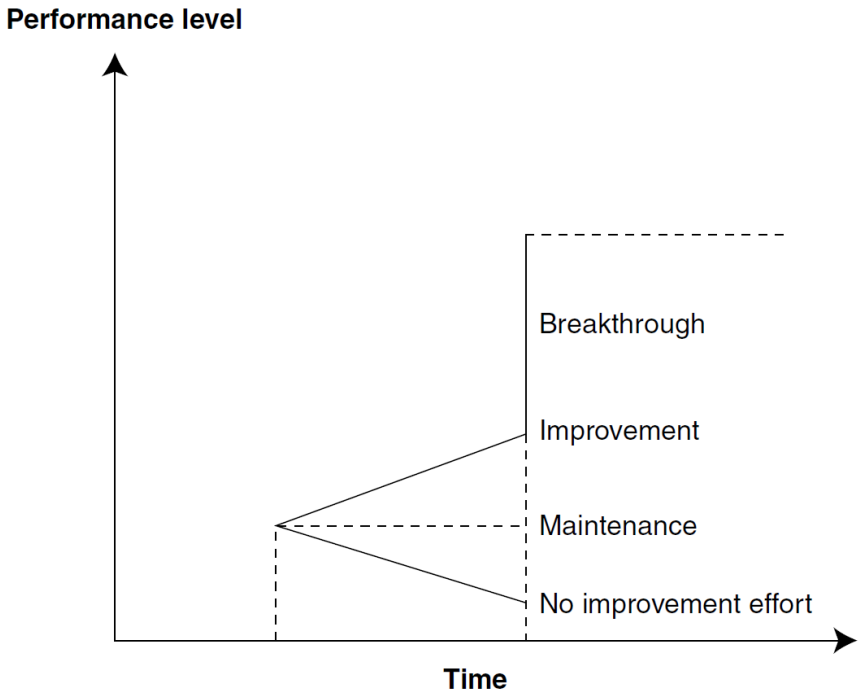

Figure 3 Effects of different levels of effort on process performance, from Andersen (2007)

When starting an improvement project, it is important to understand the current state in the organisation and the existing process (Holweg, Davies, & Meyer, 2018; Andersen, 2007; Eileen & Scott, 1995; King, King, & Davis, 2014). This is important to gain a clear understanding of what is done today and potential issues that exists. It is also important to get a sense for if the process, in its current state, is needed at all (Eileen & Scott, 1995; Holweg, Davies, & Meyer, 2018). If the findings point to the process not being needed, Eileen & Scott (1995) recommends that you start a reengineering project to drastically change the process and in turn, increase performance. However, if the process is needed, then a less radical, process improvement project should be started. King, King & Davies (2014) continues to state that to find improvement areas, it is important to identify the key pains of the organisation. These pains are often directly connected to a specific process and can be things like, high cost, unhappy employees, and late deliveries (King, King, & Davis, 2014). This is supported by Andersen (2007), who explain that it is best to start with an existing process for improvement work regardless of what tools are used later on.

To have a structured way of working with improvement there are several different models and tools that can be used. One of the most well-known models is the Deming Wheel (Deming, 1986; Andersen, 2007). What the Deming Wheel shows is that all improvement work is cyclical and should be a continuous effort, as mentioned previously (Andersen, 2007). The Deming wheel, or Plan Do Check Act model, is used to plan and execute an improvement project (Andersen, 2007). The first stage, Plan, is where the problem is analysed and actions to mitigate it are planned. The second stage, Do, involves conducting the previously planned activities. This is done to find viable solutions and to set measurements for the change to track performance. The third stage, Check, is where the performance of the suggested solution is evaluated. The fourth and last stage, Act, is where the process is actually modified based on the findings in the previous steps in order to gain

performance enhancements (Deming, 1986). However, the model's circular nature states that this is not the end of the cycle, but the beginning of a new one (Deming, 1986). The model is illustrated below in Figure 4.

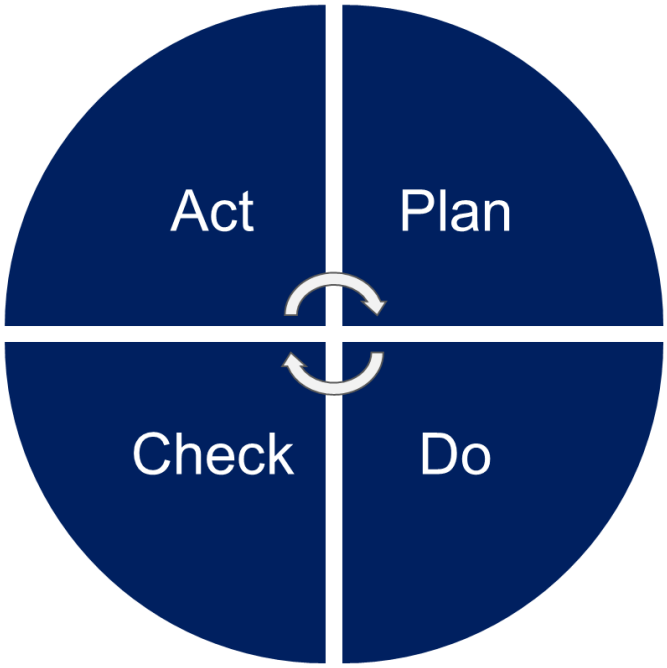

Figure 4 The Deming Wheel (PDCA model), adopted from Deming (1986)

There are other models that are more granular and breaks the improvement project down into more steps. Andersen (2007) suggests a seven-step model for process improvement which has some connections to the Deming Wheel.

The steps are as follows according to Andersen (2007):

1. Development of improvement priorities that are based on the current understanding of the overall priorities of the company to find the most important processes to improve
2. Gain an understanding of the business process as-is, and what the actual performance shortcomings are
3. Start collecting data about the identified performance shortcomings to base the intended improvement on facts
4. Apply techniques to analyse the shortcoming to understand the root-cause of the problem
5. Brainstorm about possible causes of the performance shortcomings and try to come up with ideas for improvements
6. Develop the ideas to fix the performance shortcomings by implementing new solutions or process designs
7. The last stage of the model is to implement the developed improvements, this can be one of the hardest things in the improvement project

When embarking on a process improvement journey it is important for the organisation to focus on one process at a time to be successful (King, King, & Davis, 2014). By doing this, an organisation can see breakthrough improvements which can be things like higher employee morale and performance, increased communication effectiveness internally, and increase supplier viability in the long-term (King, King, & Davis, 2014). One thing to keep in mind when trying to improve a

process is that it is not just to push in new technologies, cutting costs or rebuilding obsolete IT systems (King, King, & Davis, 2014). These things can be a part of the project but should not be the go-to solution according to King, King & Davis (2014). According to the authors, management often want to jump to these solutions without having a clear understanding or data on the process that needs to be improved.

It is also important to get an understanding of what other closely linked departments are doing in order to not do the same things (Page, 2010). This can often be the case when there are multiple stakeholders and groups involved in the same process due to the propensity for silos to form. The author continues to argue that this is sometimes because there is a lack of trust between departments which is connected to a lack of trust in the competence of the other group.

2.2 Change Management

To optimise benefits, reduce the costs and risks when implementing change in an organisation, change management plays a significant role. Change management enables an organisation to decrease risks by managing the process of implementing changes in business processes, organisational structures, job tasks and IT (Murthy, 2007). According to Holweg, Davies & Meyer (2018), every process improvement is a change project. Furthermore, Nadler & Tushman (1997) provides a model for organisational change. In their model, they recognise three problems with change and corresponding best practices related to these. The problems are described, by the authors, as the problem of power, anxiety, and control.

Firstly, the problem of power is related to people, both as groups and individuals, as they are likely to get involved in political activity when they believe that the intended change will create a major shift. This can both be positive and negative depending on their positions of power in the organisation and how they interpret the change. The best practice for problems related to power is to manage political dynamics. This can be done by getting support for the change from key power groups and to demonstrate leadership support related to the change. Furthermore, one should use symbols to visualise the importance of the change and its message. Also, Nadler & Tushman (1997) recommends building in stability by communicating to all employees what is going to change before the transition starts. The authors also recommend having a consistent level of leadership engagement to prevent eventual resistance from blocking the change.

Secondly, the problem of anxiety is related to the fear of change and how it may affect the people within the organisation. Change can create insecurities for employees about how one's job will be like in the future state. The best practice for solving problems of anxiety is to, surface and generate dissatisfaction with the current situation and to reach the appropriate levels of participation from employees in planning and implementing the change. Furthermore, it includes rewarding desired behaviour in the change into the new state, where employees are engaged, but also to provide time and space to disengage from the current state.

Lastly, the problem of organisational control describes the difficulty in monitoring goals, people, structures, and correcting performances during the change. Here it is important to develop and communicate a clear picture of the future state and how it will reward the company and employees. Also, to closely monitor the change in terms of fit among people, work, informal arrangements, and formal structures. Furthermore, to maintain control through use of special transition management devices by creating formal organisational arrangements to manage the change. It is also important to seek feedback actively on the condition of the transition state, by using natural feedback channels such as, interviews, focus groups, feedback from meetings and

surveys. The authors explain that informal channels such as face-to-face interaction between employees and managers can be very useful to obtain feedback about the condition of the change.

A change is often done, as described by Hussain, Akram, Lei, Haider & Hussain (2016), according to Kurt Lewin's change model. The first step of the model is to measure the baseline of what and how we are doing now in the current state, secondly, to unfreeze the current state and make the changes. The last step in Lewin's model is to re-freeze the new state when the changes have been done and to make the changes stick. When conducting a change project according to Lewin's model, challenges that may appear can be mitigated by using the model presented by Nadler & Tushman (1997) above.

2.3 Knowledge Management

According to Latilla, Frattini, Petruzzelli & Berner (2019), knowledge management became relevant for organisational behaviour and management in the mid-1990s. During this time, researchers saw the importance of effectively and efficiently identify, share and capture knowledge and skills in an organisation to remain a strong player in the market (Latilla, Frattini, Petruzzelli, & Berner, 2019) . Furthermore, the so called information age, where demands and requirements are becoming more complicated and the markets more vibrant, knowledge is vital to achieve success (Ameri & Dutta, 2005). Ameri & Dutta (2005) also adds that knowledge and the management of it, is needed to stay ahead of any competition. The literature recommends a discrepancy between knowledge, data, and information. Knowledge is assessed and structured information which can, with purpose, be used when solving different issues in an organization. Data in return, is untreated and disorganised facts and the information is a summed-up collection of processed data, which can be used for easier decision taking. Data and information are both simple to create, gather and influence. Knowledge is much more challenging to methodical handle. Ameri and Dutta (2005) describe that only a few percent of all the available knowledge within a typical organisation is structured knowledge. The rest of the knowledge is not structured or kept inside the minds of individuals. This unstructured knowledge is called tacit knowledge. Even though a small percentage of the knowledge in an organisation is structured, it has been proven that it can create a lot of value for companies and organisations (Ameri & Dutta, 2005).

According to Kmetz (2012) we constantly run into both tacit and explicit knowledge, where tacit knowledge is far more difficult to capture and anchor than explicit knowledge. The tacit knowledge is challenging since it is characterized be "four I's" – it is invisible, internalized, individualized, and idiosyncratic. To transform tacit knowledge into explicit knowledge, knowledge management is needed. According to Newman (2019), knowledge management is described as the collection of procedures handling evaluation, generation and practice of knowledge. In R&D, knowledge management plays a significant role, where knowledge can be utilized and re-used to enhance projects for new product development (Cantamessa, Montagna, & O, 2012). Hence, knowledge, for which is structured and processed can be used again for development of new products or services. Moreover, this information can carry customer needs, design requirements, and processes that were used when developing the product. This can in return be used in streamlining development of new products.

2.3.1 Knowledge Transfer

Hermans (2013) explains that knowledge transfer happens when people work together to solve different problems and tasks connected to R&D. As described earlier, in 2.3 Knowledge Management, several authors elaborate on the fact that sharing explicit knowledge is far less

complicated in comparison to share tacit knowledge. Therefore, it is important for organisations with teams working together to find ways to transfer tacit knowledge into explicit in order to share it. In addition to knowledge transfer in cross-functional teams, Malamed (2017) explains that the transition of tacit knowledge into explicit can be done in several ways. Moreover, one way to transfer knowledge is by demonstrating an employee's work and by making someone's work visible. Malamed (2017) explains that one way to make your work visible, is for a person to record or write down how the work was conducted. When a person has finished recording their way of working, other individuals or the organisation can recognize, sense, and acquire the tacit knowledge from this person and make it explicit. Furthermore, an effective way to transform tacit knowledge to explicit, is by online and face-to-face social networking (Malamed, 2017). In social networking, the idea is to transfer knowledge with use of the social nature of teams that collaborates, where it offers the opportunity to learn via shared education and conversations. This procedure enables communities to find innovative ideas and learning opportunities. One finding that Zhang, & Jin (2016) describes in their study, is that online social networks seem to transfer tacit knowledge into explicit more efficiently than in comparison with individual face-to-face interactions. Even though online networking seems more efficient, the authors recommends the social networking to occur online and by face-to-face interactions in parallel. Zhang, & Jin (2016) recommends this two route way in networking since not everyone in an organisation uses online platforms for communication. In addition to this, Laycock (2005) explains that social networks encourages teams to act less formally, meaning that socialising should also occur in contexts that are not only related to work since this can enhance the overall collaboration. Also, the author explains that the social networks enable members to collaborate between businesses and not just interdepartmentally. Furthermore, Malamed (2017) describes tracking of lessons learned as an effective way to gain knowledge from previous experiences, where this enables an individual to learn from an experience that he or she was not participating in. Finally, a strategy called storytelling is an effective way to transform tacit knowledge into explicit in an organisation (Malamed, 2017). The author explains, by letting experienced employees tell stories and by recording, storing and analysing the stories, tacit knowledge in the minds of these employees can be transformed into explicit.

Another method that is related to storytelling, as defined by IDEO, is downloading. Downloading is a procedure to share information that has been collected related to a topic among team members and transform it into knowledge (Design Kit, 2019). Moreover, downloading is when a participant reflects on their learnings and shares it with the team. In this method, the team takes turns to "download" without any distractions among the team members. As a part of this, when a person starts to download, the person put all their information on Post-its and uses them to describe what they experienced. When a participant is downloading, everyone else needs to pay close attention, but they can feel free to ask questions if something needs clarification The method enables a team to tell stories through experiences (Design Kit, 2019). Moreover, the experiences can be what the person saw, who they met, the facts that they gathered and impressions that they have gotten. Furthermore, the team should cluster the Post-its into groups and put them on a wall or on a board to be able draw conclusions. This method is explained by Design Kit (2019) as a powerful and rich way for a group to learn from each other and add to the collective knowledge base of the team.

2.3.2 Communication

In many cases in product development, there is need to focus on the interfaces between departments included in an R&D project (Pearson & Ball, 1993). Furthermore, product development can be defined as an activity that processes information in many ways, information

that is characterized by ambiguity and uncertainty which put requirements on the communication between departments in an organisation (Wlazlak & Glenn, 2014). To highlight the importance of communication, a case study's results showed that the external and internal communication between different functions improved R&D performance (Hung, Kuo, & Dong, 2013). The study also show that cases with more frequent meetings, shorter dialogue duration and an open environment for communication performed better than cases that did not. According to McIvor, Humphreys & Cadden (2006) the successfulness of product development in a collaboration between an organisation´s project team and their suppliers is dependent on the communication between them. To ensure high quality communication, the projects should have gatekeepers to encourage team communication outside their groups. Also, the authors explain that the success factor for improving the product development performance is the increase and variety of information that is shared in this kind of relationship. Furthermore, McIvor et al. (2006) elaborates on the issues of integrating suppliers in product development. Typical issues are; insufficient guidelines for the involvement of the supplier and that the integration of suppliers in the company systems is not done correctly. This leads to efforts of standardisation being hindered by obsolete information.

For an organisation to properly use information, a critical part of the R&D process is the communication between downstream and upstream groups involved in the development (Wheelwright & Clark, 1992). The results presented by Wheelwright & Clark (1992) showcases that internal and external communication between R&D teams significantly enhance overall performance. The communication patterns between the groups follow four different dimensions – frequency, direction, timing, and richness of media. These four dimensions describe the quality and effectiveness of the communication/collaboration and are illustrated in Figure 5 below.

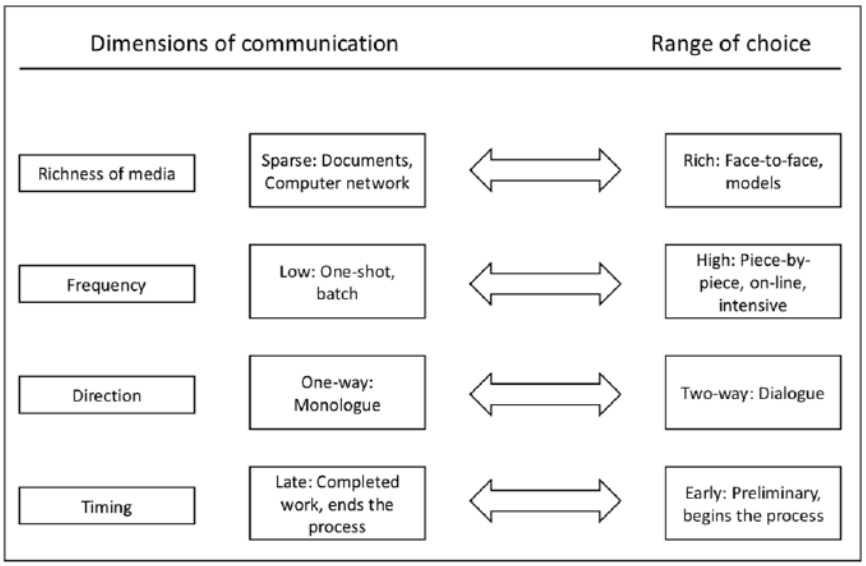

Figure 5 Dimensions of communication and interaction, from Wheelwright and Clark (1992)

The meaning of this framework is to highlight of the prerequisites for effective communication between different functions/departments in an organisation. In the figure, the communication pattern on the left side is sparse, not frequent, directed in one way and late. If this case would be an interaction between an engineer and buyer in a development process, the communication would take place late, with formal documents, containing a lack of information about other alternatives or possibilities and no or little space for feedback where late changes can occur. A desired pattern would be a rich, frequent, two-way, face-to-face collaboration that takes place early in a process, with a high level of information sharing. Hence, it is desired since it permits

more space for feedback and changes because of a higher frequency of interaction and early communication. (Wheelwright & Clark, 1992)

Based on the dimensions of communication in Figure 5, the authors have defined four modes of interaction between downstream and upstream groups that can occur in an organisation. These modes are defined as follows and illustrated in Figure 6.

Mode 1 - ''Serial/Batch mode"
The communication is one-way (upstream to downstream), sparse, late, and infrequent where the information provided is lengthy and serial. This mode can be referred as "throwing it over the wall". This mode may result in not using the potential strengths and opportunities that the downstream group has.

Mode 2 - "Early Start in the dark"
Uses the same pattern as in Mode 1, but the starting point of communication is set earlier in the development process.

Mode 3 - "Early Communication mode"
The communication is two-way between the upstream and downstream groups, moving towards real integration. The upstream work still starts well ahead the downstream group's work. The benefit of this mode is that designers will reflect a better and earlier understanding of the issues that the process engineers will face later, in comparison with mode 1 and 2.

Mode 4 - "Integrated Problem Solving"
Communication is occurring already from the start of the design phase. In this mode, the downstream group will have a flying start because they will have more information in comparison with mode 1, 2 and 3.

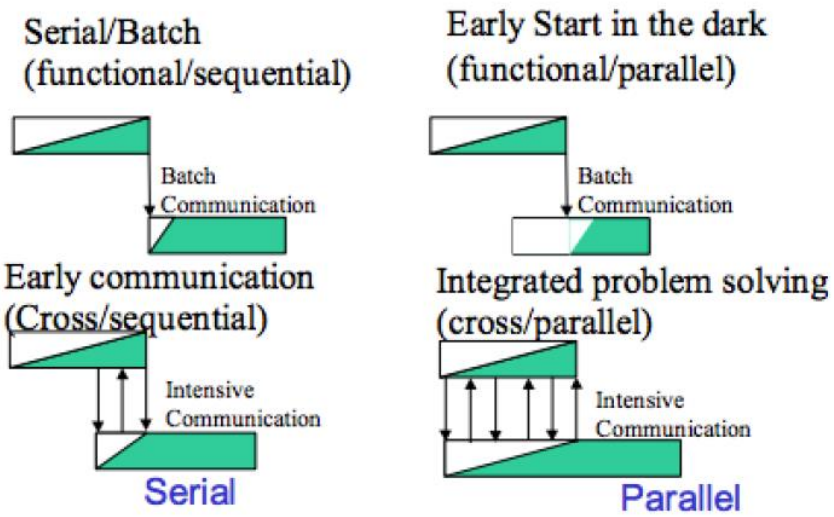

Figure 6 Four modes of interaction, from Wheelwright & Clark (1992)

Darawong (2015) points out that cross-functional communication in product development influence knowledge transfer in form of absorptive capacity. Furthermore, the author explains that it affects the absorptive capacity positively, depending on communication quality, frequency, and informality. Finally, teams can better acquire, pick up, transform, and apply knowledge if they

possess higher quality and frequency in their communication between different functional areas. (Darawong, 2015)

2.4 Quality Processes

This section will highlight the importance of standards and their purpose. Following this is a section about two of the quality tools commonly used in the automotive industry, PPAP and APQP, will be presented.

2.4.1 Overview

Standards are used to reach a desired quality outcome in product/service development. Moreover, to support this statement, the International Organisation for Standardization (ISO) explains that an organisation can benefit from standards in several ways. Organisations can, by use of standards, increase profits by offering products with increased safety, quality, and compatibility (ISO, 2019). ISO explains that an international standard is a best practice and practical information stored in a document (ISO, 2019). It is mainly a description of an agreed way of working or a solution to a global issue. Furthermore, organisations that follow standards can easier enter new markets and reduce costs by using available resources in a better way. Also, they can become more competitive on the market by offering services or products that are accepted or desired on a global level (ISO, 2019). Finally, standards enable companies to make it easier in outsourcing work tasks connected to their operations, due to a mutual understanding of requirements.

The standard ISO/TS 16949-2002 is explained by ISO (2019) as; Quality management systems - Particular requirements for the application of ISO 9001:2000 for automotive production and relevant service part organisations. The standard consists of several conditions that needs to be put on an organisation (supplier) such as, engineering specifications and to support customer engineering specifications, distribution of components and a process that can be reviewed by the buying company.

AIAG was started by employees from the three biggest North American automotive manufactures, Ford, General Motors, and Chrysler in. Today, the membership has increased where many of the top automotive manufactures are now included. (AIAG, 2019) AIAG's Quality Core Tools are the basis of effective quality management systems and they are used by most companies in the automotive industry between OEMs and suppliers (AIAG, 2019). Two of these tools are; Advanced Product Quality Planning (APQP), Production Part Approval Process (PPAP).

2.4.2 Advanced Product Quality Planning (APQP)

APQP is defined by AIAG (2019) as a guideline to help reduce the complexity of product planning for suppliers and buying organisations. This is done by letting these organisations easily communicate their product quality requirements to their suppliers. In this way, suppliers can gain knowledge and understanding in basic industry requirements and get approvals for parts developed for the buyer. Quality-One International (2019) describes that APQP is an approach which is structured for process and product design. Furthermore, they define APQP as a framework with a standardised set of quality requirements that lets suppliers design products that satisfies the customer high standards. Finally, APQP, sets the requirements of inputs and outputs in the product development process. (AIAG, 2019)

APQP is addressed by AIAG (2019) to serve the automotive industry, however, Wang J Shekar, Gong, Hou, & Chiu (2010), points out in their research that a tailor-made APQP, could also provide other industries with excellent results. APQP enables organisations to cut down costs and increase quality according to the authors' findings. Finally, Wang et al. (2019) explains that collaboration between functions might vary when using APQP, where the communication is critical for its success. Moreover, collaboration in APQP might fail in an organisation if there is a lack of communication. As APQP includes a variety of different core tools for quality assurance, Quality One (2019) explains that PPAP is one of these core tools to assure product quality.

2.4.3 Production Part Approval Process (PPAP)

AIAG has developed a process that describes requirements that are generic for production part approval, including manufacturing processes and bulk materials (Yang & Hermans, 2013). This process is named Production Part Approval Process and is a standard for the automotive industry. It ensures that product specification requirements and engineering design is met (AIAG, 2019). Also, according to Quality-One International (2019), PPAP is used in many other industries than the automotive to improve quality and communication. PPAP is linked to ISO/TS 16949, mentioned in 2.4.1 Overview and acts as a checklist of requirements. Its purpose is to enable the supplier to demonstrate the ability to provide a product that meets the customer and applicable regulatory requirements in a consistent way (AIAG, 2019). The PPAP guidelines let buying organisations and suppliers understand the requirements to each part approval of a supplier manufactured part (AIAG, 2019). In return, these principles reduce non-conformances and delays during the process of getting a part approved for serial production.

The goal of the process is to give a final approval, an approval that explains that the supplier and organisation both understands the requirements on a part. Also, PPAP shows that the manufacturing process can produce the parts according to the customer (OEM) requirements. In order to get a PPAP approval, the 18 specified elements, found in Table 1, must be completed and submitted to the buying company unless else have been specified from the buying company to supplier (AIAG, 2019). A description for each element can be found in Appendix A – PPAP Description of Elements.

Table 1 PPAP elements for submission

PPAP elements	
1.	Design records
2.	Authorized Engineering Change Documents Customer Engineering approval
3.	Customer Engineering approval
4.	Design FMEA
5.	Process Flow Diagrams
6.	Process FMEA
7.	Control Plan
8.	Measurement System Analysis Studies
9.	Dimensional Results
10.	Material, Performance Test Results
11.	Initial Process Studies/ Capability Study
12.	Quality laboratory Documentation
13.	Appearance Approval Report (AAR)
14.	Sample Product
15.	Master Sample
16.	Checking Aids

17.	Customer Specific Requirements
18.	Part Submission Warrant (PSW)

Quality-One International (2019) and AIAG (2019) both explain that it is not always necessary to submit all the elements for a PPAP approval. The level of submission from the supplier to the buying organisation depends on four levels. The description of documentation requirements for each level can be found in Appendix B – Documentation Requirements Depending on Submission Level (AIAG).

- **Level 1** – Part Submission Warrant (PSW) is only requested and submitted to the customer (buying organisation)
- **Level 2** – PSW with limited supporting data and product samples is submitted
- **Level 3** – PSW with product samples and complete supporting data is submitted
- **Level 4** – PSW and other requirements as defined by the customer (buying organisation)
- **Level 5** – PSW with product samples and complete supporting data available for reviews at the supplier's manufacturing plant

The level of submission if often stated in the quotation between the buying organisation and the supplier (Quality-One International, 2019).

3. Methodology

This chapter outlines and explains the methodology used in this thesis. The methodology is presented to give the reader an understanding of how the authors came to the recommendations and conclusions presented in the end of the thesis. First, the overall research process is explained followed by the selected research strategy and design. The following section explains the data collection methods used in the thesis and after that, quality criteria are discussed. Lastly, ethical considerations are outlined to show how the authors have taken these considerations into account when conducting the thesis.

3.1 Research Process

The research process of this thesis was linear to a large degree but with the additions of iterative processes in certain steps. Firstly, to fully understand the underlying challenges that the large OEM face, an initial examination of the current state was performed. This process intended to surface most issues that occur when performing the PPAP at the company. Bryman & Bell (2011) states that this is a good strategy in order to narrow down the overall research scope and to prioritise focus areas.

Following the initial problem inventory, the scope was defined together with key stakeholders to align our views on the research subject. This was done to create consensus and a common view of the purpose of the thesis. This stage was important because of the open nature of the research. The expectations and goals were aligned with key stakeholders to ensure that the thesis was focused on the most pressing challenges.

Based on the identified and agreed upon scope, the thesis continued with data collection. The methods used in this phase were a literature review and interviews combined with observations. These were used to gather data from both academic sources and on a company level. The interviews, observations and literature review were conducted in tandem which enabled the authors to use the methods as input to each other. Finally, the data was analysed and condensed into a clear description of the identified challenges and recommendations on how to mitigate them. The improvement recommendations were discussed during sessions with key stakeholders to make them feasible in the organisation.

In Figure 7 below, the research process is conceptualised to show the research process.

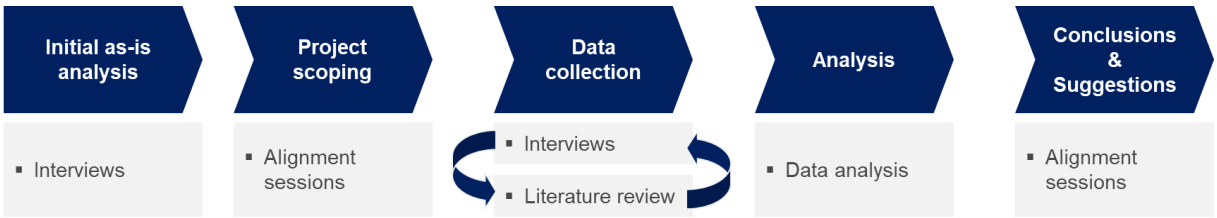

Figure 7 Research process illustration

3.2 Research Strategy and Design

This thesis was based on analysing an organisation and the dynamics within which can be hard to define (Waller, Farquharson, & Dempsey, 2016). According to Bryman & Bell (2011), it is

therefore best to use an inductive approach. Inductive theory is built on the notion that empirical observations and data collection form the basis for new theory (Bryman & Bell, 2011). The use of an inductive approach aligns well with a qualitative research strategy (Bryman & Bell, 2011) and this thesis is therefore mainly built upon this. This is further supported by Waller, Farquharson, & Dempsey (2016), who state that when studying an organisation's culture and how it cooperates internally, a qualitative strategy is the most suitable.

The selection of a research design provides an underlying framework for data collection and data analysis (Bryman & Bell, 2011). The study was designed as a case study where a large OEM and it's purchasing organisation was the main focus. A case study can be defined as a focused study of a single case where you use interviews and/or observations to map, for instance, a company under a period of time (Bryman & Bell, 2011). This design was selected due to the complexity of the research subject and the need to understand the organisation at a granular level.

3.3 Data Collection

To gather data to fulfil the purpose of the thesis, three methods of data collection were used, literature review, interviews and, observations. The following sections explain how the methods were used and the reasoning behind their selection.

3.3.1 Literature Review

For the authors to get enough knowledge about the challenges under investigation and to connect these challenges to previous studies, a literature review was performed. This resulted in a theoretical framework that covers the areas under investigation and gives the reader an understanding of the underlying themes of the thesis. The study was performed in combination with interviews to create a holistic view of the identified challenges and their underlying themes. Bryman & Bell (2011) states that the literature review is a good way to build knowledge about the research subject and to justify the research question and research design. To find relevant articles and books in areas connected to the proposed research questions, keywords were used. The following keywords, and combinations thereof, were used:

Business Process Management, Process Improvement, Change Management, Communication, Cross-functional Teamwork, Knowledge Transfer, Knowledge Management, Standards, Advanced Product Quality Planning, APQP, Production Part Approval Process, PPAP, Quality Processes.

3.3.2 Interviews

In conjunction with the literature review, interviews were conducted with employees at the company with direct or indirect knowledge of the activities related to the PPAP. To find the appropriate individuals to interview, a form of purposive sampling called snowball sampling was used. Purposive sampling is a technique where a certain number of criteria are selected to find interviewees that have the right experience to help answer the research questions (Waller, Farquharson, & Dempsey, 2016). The criteria used were, firstly, that the interviewee should have a direct connection with the PPAP and secondly, that they should be employed in one of the five departments working with supplier quality at the OEM. The "snowball" comes into consideration when the interviewees recommend new individuals to interview (Waller, Farquharson, & Dempsey, 2016). This sampling method was selected because the authors needed help identifying individuals with the right knowledge within the company. The selected sampling method also

works well in combination with a qualitative research strategy due to its ability to adapt to new information (Waller, Farquharson, & Dempsey, 2016).

To capture a holistic view of the company, the authors interviewed employees from different levels of the company. This was done to capture a complete picture of the identified challenges. A manager might see the PPAP in a different light than an SQE which is important to capture to draw generalizable conclusions. In total the authors interviewed 29 employees at the OEM for a total of interviews.

The interviews were semi-structured in nature, to give the interviewees freedom to elaborate around the presented topics. This interview design is well suited in qualitative study since it enables the authors to capture subtleties and the point of view of the participant (Bryman & Bell, 2011). The interviews were conducted face to face when possible to as much information as possible. This is a good strategy according to Waller, Farquharson, & Dempsey (2016), since it gives the interviewer the possibility to see body language and other things that enhance the interview data. In those cases where a face to face meeting was not possible, the meeting took place on Skype for Business. During the interviews, both authors took notes to ensure that all relevant information was captured. The notes taken were aimed at capturing only the relevant data to not intrude on the privacy of the interviewees. To make sure that the interview felt comfortable the decision was made to not record the interviews, since it can have a negative effect on the openness of the discussions (Waller, Farquharson, & Dempsey, 2016)

3.3.3 Observations

To get the full picture during the interviews, observations were used to see into the actual workflow of the interviewees. Due to the nature of the work, observations in real-life situations was deemed too hard due to the large amount of hidden knowledge used in each step. Therefore, the authors used observations during the interviews to capture the workflows of the interviewee.

When performing the interviews, the authors asked the interviewee to describe their workflow first and later to demonstrate how they performed each step. This was done to find gaps in their explanation and actual behaviour. Waller, Farquharson, & Dempsey (2016) state this usage of observations is favourable to enable verification that people do what they say they do. Bryman & Bell (2011) further argues that, there are several advantages using both interviews and observations since they complement each other well. When observing how a person performs a task the interviewer can pick up things that the interviewee takes for granted and does not mention during an interview.

3.4 Analysis of Data

In order to analyse the data gathered from the interviews and observations, two methods from the 7 management tools were used, the affinity diagram and the interrelationship diagram (Munro, Ramu, & Zrymiak, 2015).

The affinity diagram is described by Munro, Ramu, & Zrymiak (2015) as a way of finding potential answers to open-ended question. The method is built on categorising and grouping the qualitative data to find groups with the same themes. The grouping should be conducted iteratively until there is a manageable number of themes left. The authors used the method to find central themes in the qualitative data that could be used as input to the interrelationship diagram. Furthermore, from the interviews the authors counted the number of times a challenge was mentioned to highlight what unique challenges that the interviewees had in common. This was done to make

sure that the challenges were real experiences and not just single cases that occurred to one individual. The count of each individual challenge was then aggregated when themes were formed thus adding up to the total amount for each main theme. The affinity diagram is visualised in Figure 8 below.

Figure 8 Affinity diagram illustration

The interrelationship diagram is a method that can be used to find cause-and-effect relationships from challenges (Munro, Ramu, & Zrymiak, 2015). The method begins with the participants placing notes with challenges written on them on a board in no particular order. The second step is to systematically evaluate the relationship between the challenges. Arrows are used to symbolise if the challenge causes or is caused by the other challenges. In this way it is possible to see how they affect one another. The one with the most arrows pointing out from it, is deemed the driver. This means that this challenge is a key part of the issues at hand. This method was used by the authors as a way of evaluating the identified challenges that was most interesting to focus on when moving forward with the thesis. The method is visualised below in Figure 9.

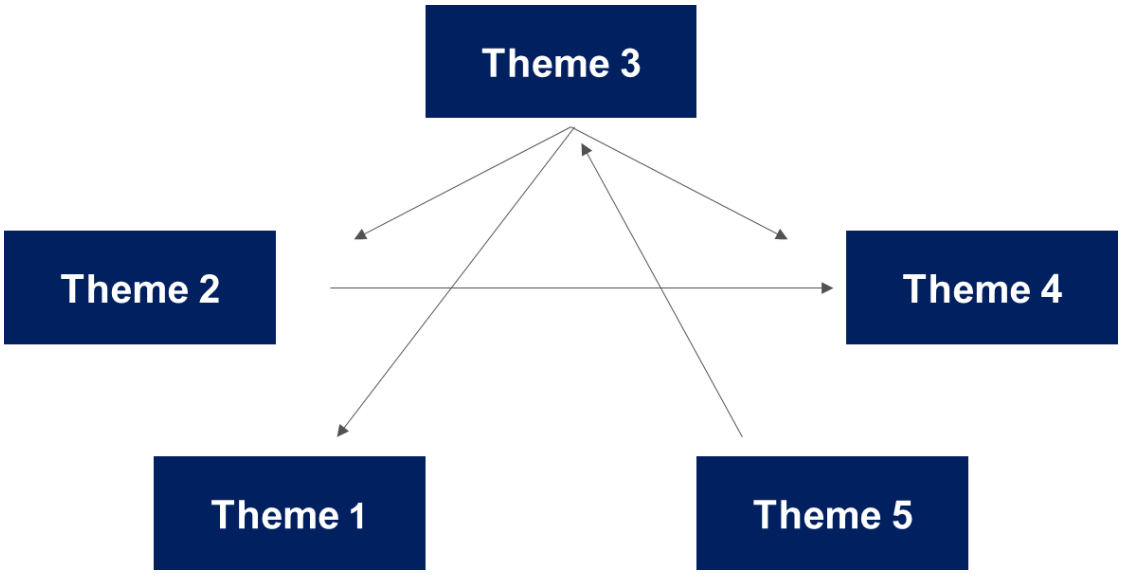

Figure 9 Interrelationship diagram illustration

3.5 Research Quality Criteria

To ensure that the conducted research is of high quality the authors aimed to uphold high standards in important research quality criteria. Bryman & Bell (2011) writes that when conducting qualitative research reliability and validity is important to consider. The authors also state that there are parallels to validity and reliability that can be used to assess quality, trustworthiness, and authenticity. To capture the most important quality criteria that match the design of the study validity, reliability and a part of trustworthiness and credibility was used.

For a study to have validity, the conclusions drawn from the research should have integrity (Bryman & Bell, 2011). This means that the conclusions should be consistent with the real world. This thesis was mostly based on qualitative data and this indicated that there would be difficulties in validating measurements of the study (Bryman & Bell, 2011). However, by having a high level of interaction with the employees at the OEM a high level of ecological validity was achieved. Ecological validity describes how well the social findings fit into peoples' natural setting (Bryman & Bell, 2011).

It is also important to take reliability into consideration when conducting a qualitative thesis. Reliability is in large parts connected to the repeatability of the study (Bryman & Bell, 2011). As mentioned previously, the data was mostly derived from personal communication with employees and is therefore at risk of being subjective and biased. This indicates that the reliability of the study is rather low. However, by corroborating answers and interviewing a large set of 29 employees the authors aimed to increase reliability.

In order for the research to be believed and accepted, it is important to use good practice when conducting the study (Bryman & Bell, 2011). This can be managed by using two techniques called member validation and triangulation (Bryman & Bell, 2011). Member validation is a method that uses the research subjects to confirm or point to areas that do not adequately describe their situation (Bryman & Bell, 2011). This method was used continuously during the thesis with key stakeholders to ensure that the authors' findings were deemed consistent with the real situation. Triangulation is the use of multiple sources or methods to acquire data that correctly shows the true picture of a subject (Bryman & Bell, 2011). This was achieved by combining interviews with observations and by corroborating data between interviewees and comparing the results.

3.6 Ethical Considerations

In a thesis study which involves many different stakeholders and people, it is important to take ethics into consideration (Waller, Farquharson, & Dempsey, 2016). There are three main ethical considerations to consider for this thesis, respect, confidentiality, and inclusion.

Respect is according to Waller, Farquharson, & Dempsey (2016) mainly about the individual's self-determination and rights. Since this study was based on interaction and interviews with employees it was crucial to get their consent when interviewing them and using their input. It is important to get informed consent from the interviewees to make sure that they are aware of the research and the intended outcomes (Bryman & Bell, 2011). The authors gathered this verbally at the beginning of each interview to make sure that the interviewees were fine with the use of their input in the thesis.

Secondly, to ensure that the people involved in the research are comfortable and feel that they can be open with issues and other input, confidentiality is important to ensure. This was ensured by anonymising interviewees and making sure that their identity cannot be deduced by their input

or other factors. It was also important for the authors to ensure internal confidentiality. This means that the interviewees should be protected from identification from other research subjects as well as from people outside the study (Tolich, 2004).

Finally, this thesis aims to be inclusive and it is therefore important to use ethical considerations when sampling. Waller, Farquharson, & Dempsey (2016), writes that sampling should be done without excluding any group or individual for non-relevant reasons. The selected sampling method will be based on competence and experience and will aim to capture subjects from a representative group from within the organisation (Waller, Farquharson, & Dempsey, 2016).

4. Empirical Findings

In this chapter, the empirical findings from the interviews and observations are presented. The findings holistically explain PPAP at the OEM, the generic time plan in a project and how the PPAP elements link to the time plan. Furthermore, the OEM specific requirement called RTS is presented followed by the identified challenges in relation to the PPAP and generic time plan. This chapter aims to answer the first and second research question stated below.

RQ1

How do the SQEs work interdepartmentally and with their suppliers in order to approve a PPAP?

RQ2

What challenges are the SQEs facing when working towards a PPAP approval in collaboration with suppliers and interdepartmentally?

4.1 PPAP at the OEM

According to the interviews and observations of internal documentation, the OEM follows the AIAG requirements for APQP and PPAP that are applicable for the products they produce. The PPAP proves that the manufacturing process used to produce parts for the OEM is fully developed, thoroughly tested, and capable of serial production of parts conforming to the technical specifications such as drawings and quality criteria. A PPAP can be ordered by the OEM in the following ways:

- When there is an introduction of a new part,
- Modifications to an existing part,
- Specification and drawing changes related to a part
- Corrections to a prior inconsistency of a part
- Supplier process change at their manufacturing site
- Substitutions or changes of material
- Changes of sub-tier suppliers (where a supplier uses another supplier to supply from)

Sample parts are components that have the exact same design as the intended components for serial production. When sample parts are produced by the suppliers, they are submitted together with the supporting documentation to the OEM. These parts and supporting documentation shall show evidence that the design records and specifications have been properly understood and met by the supplier. Furthermore, it shows evidence that the manufacturing process has the capability to produce conforming parts in the actual production environment. Lastly, it demonstrates that the supplier's manufacturing process has the capacity to support production quantities at a consistent level. The OEM requires PPAP approval prior to shipment of any component for use in customer products.

For PPAP approval to be granted from the OEM, the sample parts need to be manufactured with the intended serial production equipment and methods by the suppliers. This means that the production run is done at the production site, at production rate and with production tooling, gaging, materials, and operators. Furthermore, it means that the parts are tested and measured according to specifications. As part of these prerequisites for PPAP approval, the elements described in Appendix A – PPAP Description of Elements (AIAG) needs to be performed by the supplier and show evidence that the part conforms to the OEM requirements. The evidence is the

documentation of each element. In PPAP, the SQE is responsible to check the evidence (documentation), which the supplier submits to the OEM, and to give a PPAP approval. Further, the documentation that is required to be submitted is stated in the submission level, described in Appendix B – Documentation Requirements Depending on Submission Level (AIAG). In order for the supplier to succeed in PPAP, the SQE supports the supplier in quality assurance activities. Product Approval (PPAP approval) consequences in the supplier getting their final payment of the tooling investment and the first shipment of components is allowed.

4.1.1 Generic Time Plan

According to the interviews, the different departments follow a generic time plan at the OEM for product development. The timeline describes the timing of different activities to a generic project time plan and how the activities link to each other. A holistic illustration of the generic time plan is presented in Figure 10 below. The generic time plan visualises how a project is taken from an idea through different stages to a finished product, passing through several gates. At gate 1 to 4 there are four different releases based on the maturity of the product/products. When a project has passed through gate 4 (Final verification), a product release is conducted which means that a component's design reflects a part ready for serial production. In the stages between the releases/gates, product development activities are conducted. In addition to these activities, a lot of different quality assurance activities are conducted in a collaboration between the product development department, SQEs and suppliers.

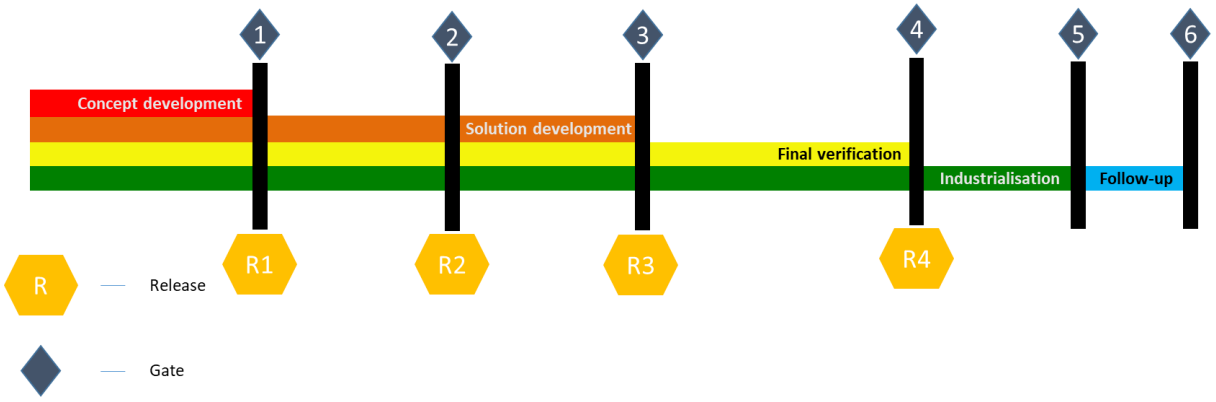

Figure 10 Generic Time Plan at the OEM

In relation to the generic time plan, in a project, the SQE is involved early. Moreover, when involved early the SQE performs supplier evaluations prior to a supplier selection and they give input regarding quality aspects to the supplier selection done by a sourcing board. Supplier selections are made with criteria such as quality and cost, which means that the input from the SQEs is crucial for the supplier selection. The selection of a supplier is done with different timing in relation to the generic time plan. The timing is depending on if the supplier is developing or only producing components for the OEM. In connection to the generic time plan, the OEM uses APQP to assure quality for the products/components in collaboration between the stakeholders. Components for the OEMs products are classified into two distinct groups, components that are critical and non-critical. Critical components have special characteristics or are safety critical, and therefore they need more attention and reviews by the SQE when they collaborate with the suppliers and the product development department. Furthermore, with critical components, the

SQE is responsible to perform APQP reviews with the supplier. These reviews are conducted to make sure that the suppliers are staying on the right track and that the development is following the initial co-signed time plan, in relation the project master time plan. Furthermore, non-critical components do not require APQP reviews from the SQEs as they need less attention from the stakeholders when developing, but the supplier is obliged to always follow an APQP internally, aligned with the generic time plan, when developing components for the OEM. For a critical component, the APQP kick-off, in case of a developing supplier, occurs prior Release 1 (R1). In case of a producing supplier, the kick-off occurs right after Release 2 (R2). The different APQP reviews are illustrated in Figure 11.

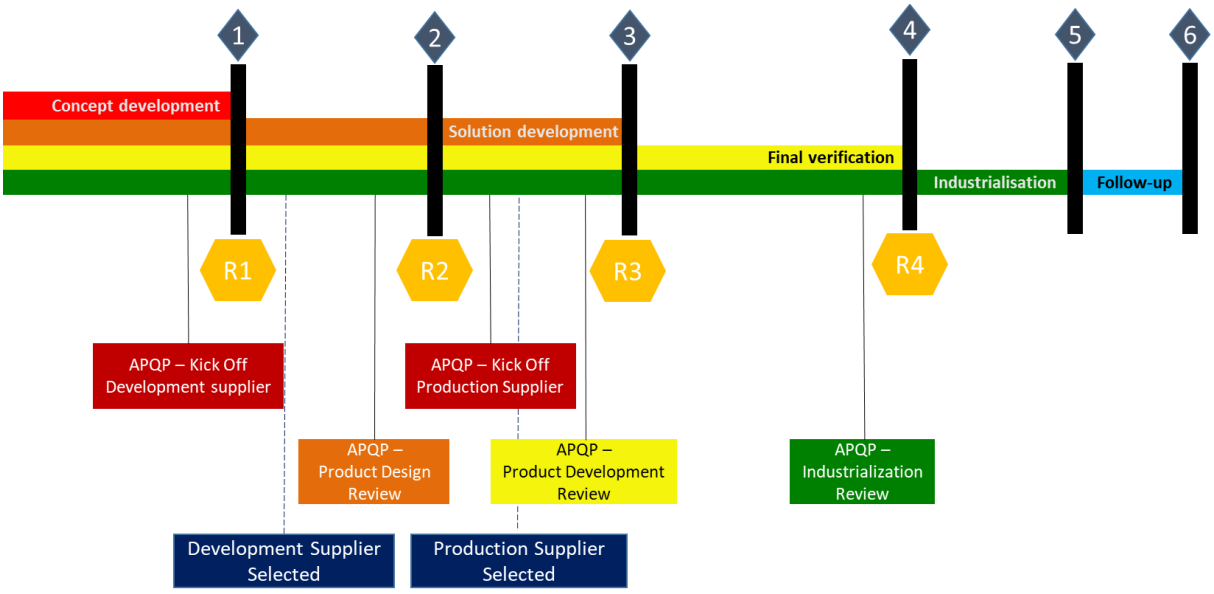

Figure 11 APQP reviews and supplier selection timing

4.1.2 PPAP Elements

PPAP is the final step of the APQP at the OEM. For PPAP in relation to the generic time plan, the different elements, found in Appendix A – PPAP Description of Elements (AIAG), are finished and recorded by the supplier prior a PPAP approval. In a project, a PPAP is normally ordered just after Release 3 (R3). Furthermore, the order is issues by a buyer, and it carries information on what is needed to approve the part and process used to produce the part. Also, the order contains information about the PPAP due date when it should be approved for serial production. With the PPAP order being submitted, the supplier will get notified that a PPAP is required and the SQE can together with the supplier, start preparing/finishing the PPAP documentation needed for an approval. The documents needed for an approval, depends on the decided submission level, both described in 2.4.3 Production Part Approval Process (PPAP), and if the SQE and supplier have agreed on additional document submission. The generic time plan with regards to PPAP can be found in Figure 12.

When Gate 4 has been passed, an amended PPAP order is done by the buyer, normally two weeks later. The SQE require that all documents submitted from the supplier should be finished and sent to the SQE two weeks before the PPAP approval date, to have time to check the documents. If there are any deviations for the component, a date for an interim PPAP approval is given. The deviation can depend on missing technical documentation to support that the design reflects a serial production ready component. Depending on the interim status, the ones responsible for solving

the deviation must act to reach a final PPAP approval. The SQE is responsible to give a PPAP approval and to sign the Part Submission Warrant (PSW) submitted together with the required supporting documentation for the PPAP. One important step, prior the submission of documentation, is to assure that the manufacturing processes used, and the products produced at the supplier is conforming to the OEM requirements. This step is called Significant Production Run (SPR). Furthermore, a SPR enables the SQE to check the manufacturing processes, their production rate and quality of the process/component. The outcome of the SPR is documented to show evidence that the processes meets the requirements from the OEM.

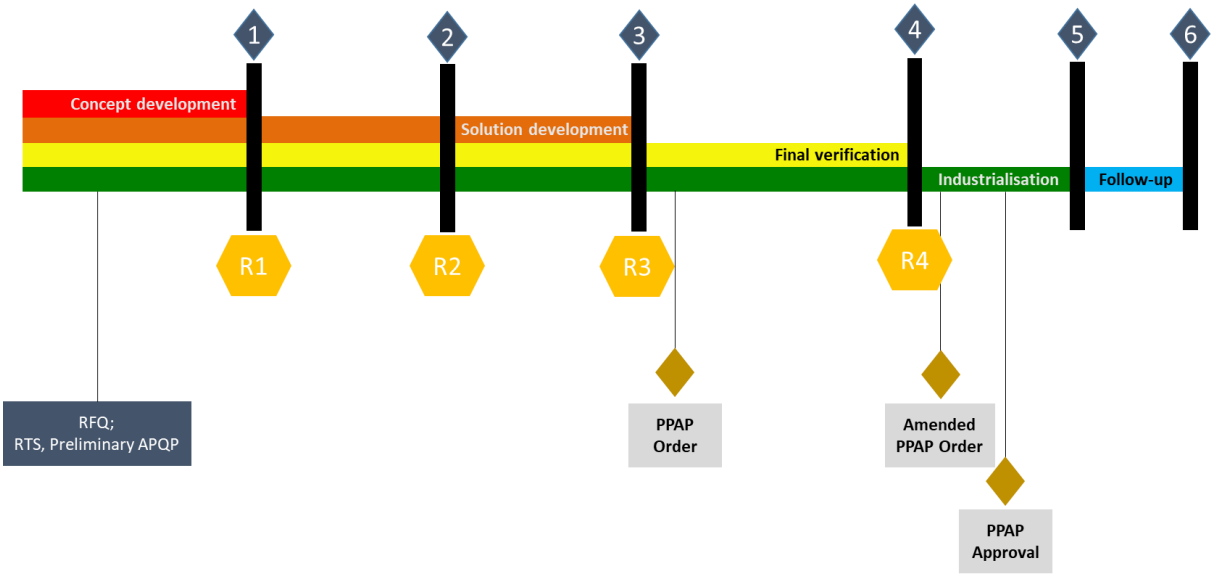

Figure 12 PPAP timing in relation to Generic Time Plan

As described above, two weeks before the PPAP approval date, the supplier is obliged to submit the supporting evidence to the SQE. The SQE sets the approval (or deviation if there is any) in an IT system, by ticking a box, which makes the status of the component transparent in the whole organisation. The different activities and responsibilities that are performed for PPAP after Release 4 (R4) to a PPAP approval is illustrated in Figure 13.

Some of the elements in PPAP at the OEM that requires major cross-functional teamwork and communication are the Design FMEA, Process FMEA, Checking aids and Records of compliance with the OEM specific requirements. According to the interviews, these elements also require that the OEM works proactively together and with their suppliers to be able to reach the desired outcome. Since the Process FMEA is based on the outcome of the Design FMEA, it is essential that the Design FMEA is thoroughly done by the product development department and submitted to the supplier in case the OEM develops the component in-house. In return, it is important that the supplier performs a thorough Process FMEA. For the SPR, it creates a clear picture for the SQE of the supplier production capability and the earlier it can be performed the better the outcome will be.

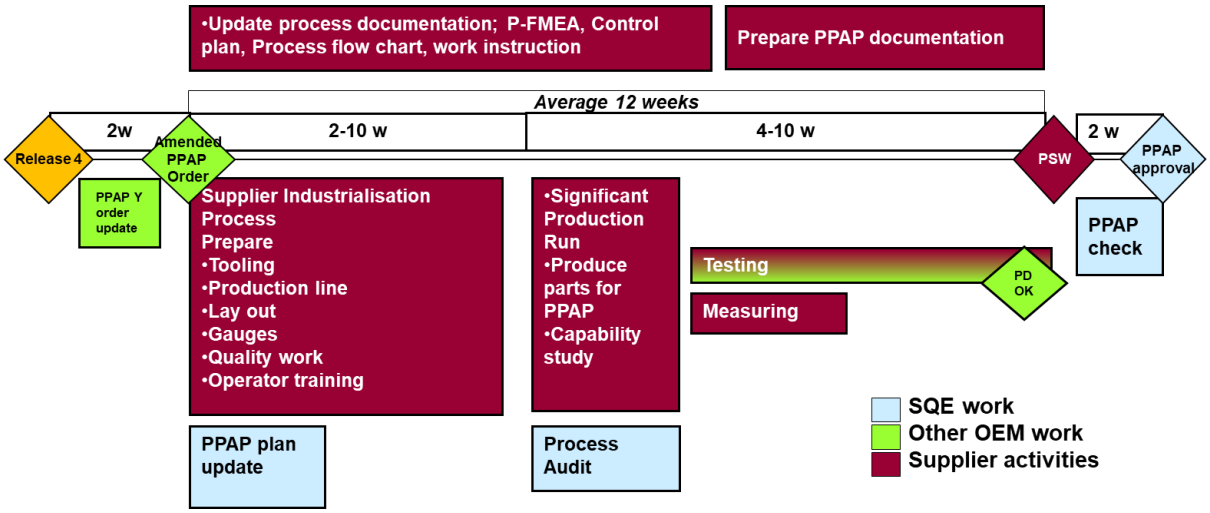

Figure 13 PPAP activities and responsibilities in a generic project

The OEM specific requirements (named Customer Specific Requirements in Appendix A – PPAP Description of Elements (AIAG)) are essential for the success of the OEM's products. In addition to the activities in APQP, the OEM has developed these activities to support the process of new part introduction in serial production. The specific requirement that is the most important for the SQEs, where they support early in relation to the generic time plan, is the Review of Technical Specifications (RTS). As mentioned earlier, the OEM specific requirements, require close cooperation between the members of the OEM and supplier's project teams. For the SQEs, they are involved early where they support the supplier in answering the RTS as part of the Request for Quotation (RFQ). The activities formed out of these specific requirements expect all project members to participate and the activities should be included in the supplier's project plan. Finally, the RTS is submitted by the supplier to the OEM prior the PPAP approval date.

4.1.3 Review of Technical Specifications

The OEM specific requirement called Review of Technical Specifications (RTS) is a document that aims to make sure that the supplier fully understands the technical requirements on the part that they will produce. The document consists of 12 different steps where items such as, drawings, technical requirements, special and critical characteristics, should be covered. The OEM aims to gather all the technical documentation related to the part for the supplier to review. The RTS connects to both ISO 9001:2008 and ISO/TS 16949§7.2.2 with regards to "Review of Requirements related to the Product". In these standards, it is stipulated that the suppliers are responsible for organising designs reviews to get a thorough understanding of the OEMs technical specification. These reviews should be recorded and made available for the OEM to enable constructive discussions regarding requirements. The RTS should be sent out as a part of the Request for Quotation at an early stage in process to ensure that potential risks and issues can be captured as early as possible. This should then be filled out be the supplier and sent back to the OEM and work as a living document until the part is deemed ready for serial production. The RTS is, in the end, a part of the PPAP documentation due to its importance for part quality. Below in Figure 14, the distinct stages of the RTS is outlined in connection to the generic time plan.

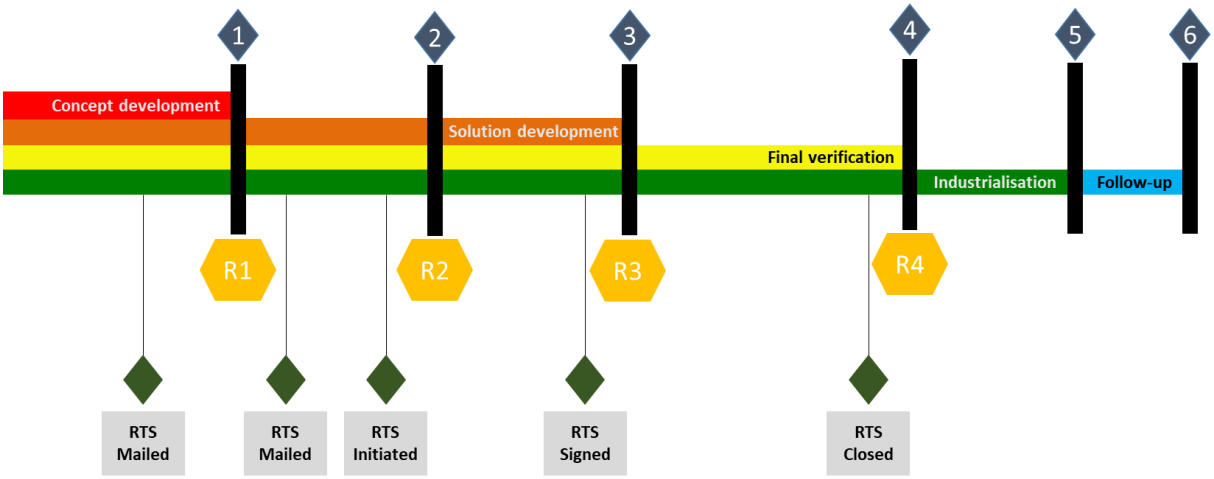

Figure 14 RTS timing connected to Generic Time Plan

As mentioned above, the RTS is created to ensure that all requirements are understood by the and that they can be fulfilled. The main purpose of the RTS is to ensure this by conducting joint reviews of the technical documentation connected to a part between the supplier and the OEM. The main points the OEM wants the supplier's agreement on is:

- That the set requirements of the part are achievable,
- That production of a fully conforming part is possible
- What measurements should be done on concept parts

The OEM can also use the RTS to tap into the extensive experience suppliers often have with producing parts. This means that the supplier can give the OEM valuable advice and guidance on possible part improvements in the initial stages of development. This enables the OEM and the supplier to avoid late changes to the design and tooling which can have negative impacts on cost, quality, and delivery times.

According to the interviews, the RTS is a crucial part for the overall quality of the part since it enables early involvement from all stakeholders in a cross-functional way. The SQE sits down with the supplier and walks through the documentation and the requirements to make sure everything is understood. They are supported by the design team and buyers which creates a cross-functional bridge between the different areas working to finalise the part. During the interviews, it was also noted that this was a key success factor for most PPAPs since the process is in nature cross functional. Another aspect of the RTS that the interviewees often mentioned was the importance of questioning the supplier during the RTS reviews. This is to ensure that the supplier has looked at the requirements closely enough and thought about the potential challenges that could occur. One interviewee stated that an SQE should expect comments and potential challenges for many of the requirements since that shows the supplier is determined to fully understand everything. This is also important since the supplier needs to sign the RTS to get the job which further motivates them to assure the OEM that they can fulfil the requirements.

As mentioned above, the RTS is initiated as part of the RFQ which means that more than one supplier often fills out the RTS material. The status of the RTS is in this stage "RTS Mailed" which is shown in Figure 15 below. Depending on if it is a developing or producing supplier the timing is different for this status. The SQE has a supporting role in the work with the RTS and the PD

owns the document. This puts great demands on the SQEs since they need to act as an intermediary between the OEM and the supplier.

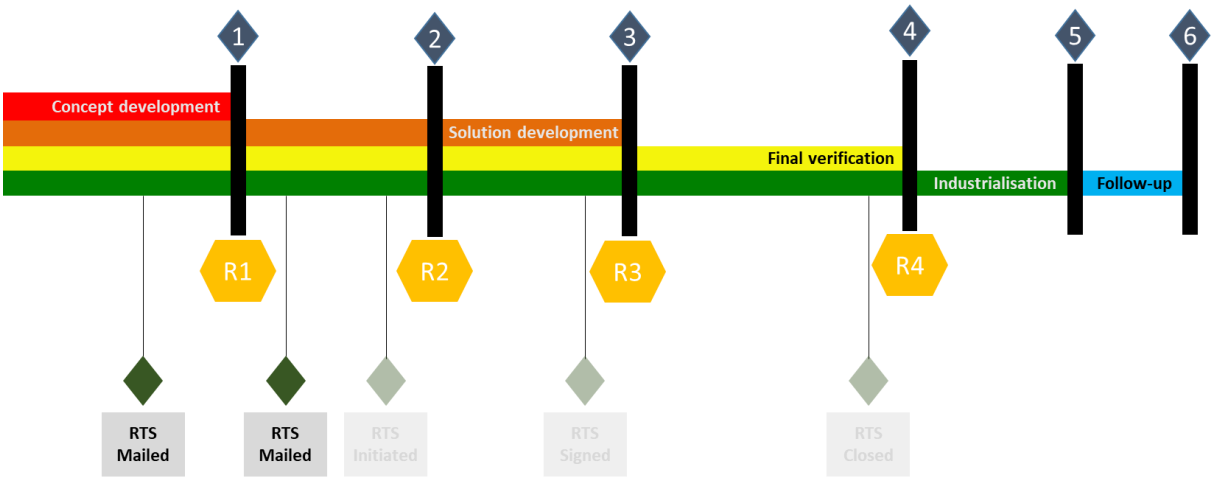

Figure 15 Timing of RTS Mailed status

The RTS is initiated by the PDs who gather all relevant technical documentation for the Buyer to send over to the potential suppliers before final supplier selection. The SQE start their work with making sure that the RTS material is understood for the supplier to review the documentation correctly and with enough thoroughness. This stage is most often performed by the SQE for new suppliers that have not worked with the OEM before. According to the interviews, this stage was seen as important to mitigate the risks of selecting a supplier that in the end cannot deliver on the high requirements from the OEM.

When the suppliers send back the filled in RTS, the SQE supports the PD in analysing the answers to get an idea of which supplier is the most suitable from a quality and production perspective. When the answers have been analysed a face-to-face review is called to go through the RTS and discuss all aspects to make sure that the requirements are fully understood. During this review, the SQE and technical staff from the supplier discuss requirements to clarify questions and highlight potential challenges. In this stage, the SQE has a significant impact on the success of the part since it is at this stage challenges are the easiest and least expensive to fix. It is also important for all stakeholder to have clear lines communication to ensure that everybody involved is working with the latest information. When this stage is initiated, the status of the RTS is set to "RTS initiated" as shown in Figure 16 below. This is then followed by an official supplier selection which builds on the findings from the RTS among other things.

When the supplier has been selected, the SQE's responsibility is to support the PD in mitigating the identified risks in the initial RTS. The part design is still immature, changes are probable which can lead to a need to update the RTS. The supplier then needs to perform the same exercise again and send it back to the buyer who is responsible for communicating the update to the PD and SQE. This again points to the cross-functional nature of this process and the need for frequent communication between all stakeholders to ensure everybody is up to date. The process is also highly dependent on knowledge transfer since all functions involved needs to share their knowledge and experience to bring potential challenges up to the surface early. The supplier should in this stage also request additional formal RTS reviews if proposed design changes will

have a significant impact on their ability to deliver what was promised. The SQE will then offer support and guidance to make sure the supplier can move forward.

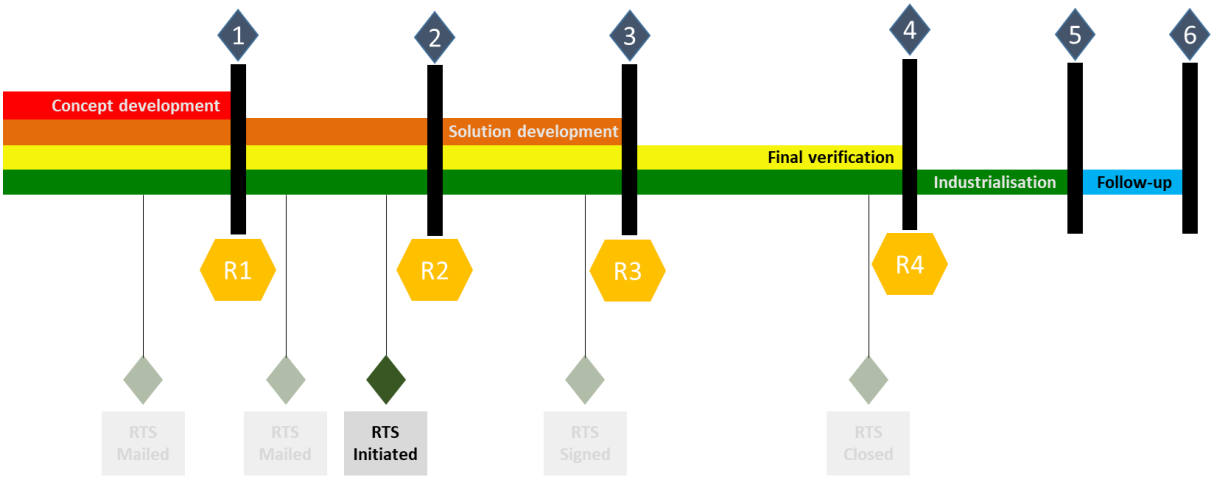

Figure 16 Timing of RTS Initiated status

When all technical material has reached a sufficient level of maturity, the part is ready to move from the Solution Development stage to the Final Verification stage, depicted in Figure 10. When this happens, the RTS needs to be signed by SQE, Buyer, PD and supplier ensuring that all stakeholders are in consensus about what needs to be done to bring the part to series production. For the RTS to be signed the supplier needs to fully understand all requirements and all outstanding concerns should be matched with a corresponding action plan. The SQEs plays a key role in this stage, in that they need to facilitate the knowledge transfer between the OEM and the supplier. Their experience is crucial for the success of the part and, as stated by several interviewees, the most crucial time to use that experience is in the initial stages of the process. The SQE should in this stage review the RTS with the supplier together with the latest documentation. This is done to ensure that all challenges, based on the current material, have been found and that the mitigating action can be finalised before the part is set to go into production. The results of this review are important to anchor with the other departments cross-functionally. The SQE needs to gather further information from the other departments at the OEM which gives the SQE a holistic view of the actual status of the document. When all parties are in agreement and the RTS has been signed, the OEM status for the RTS is set to "RTS signed" as shown in Figure 17 below.

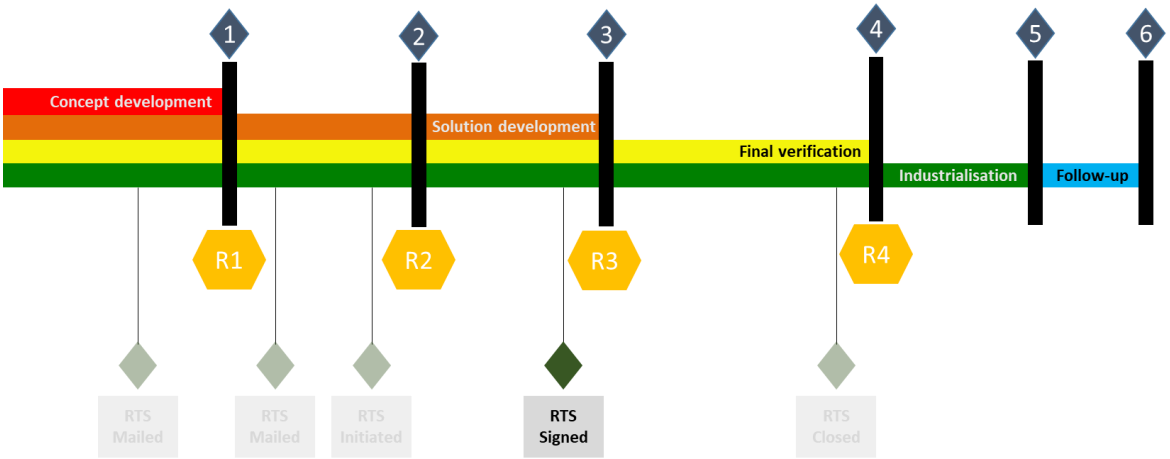

Figure 17 Timing of RTS Signed status

The action plan agreed upon when signing the RTS is continuously worked on to finalise the part to the specifications of the OEM. The final technical requirements, drawings, and specifications start being finalised and moves towards the stage where it should be closed. This should be done prior to the move to the Industrialisation stage of the process. The same methodology is used as before the RTS Signed stage where the latest documentation is added to the RTS if there have been changes. This is then checked during a review with the SQE, stated before, to ensure that no new issues will be raised after the RTS is closed. The requirements for closing the RTS are:

- Supplier reviewed the final documentation for R4 release
- Agreed action plans have been integrated into the R4 documentation
- No additional issues left between the OEM and supplier and the supplier agrees to deliver parts fully conforming to the R4 release documentation

When these requirements have been fulfilled the SQE, PD, Buyer and supplier, can close the RTS by signing and archiving it. The timing of the closing of the RTS is shown in Figure 18 below.

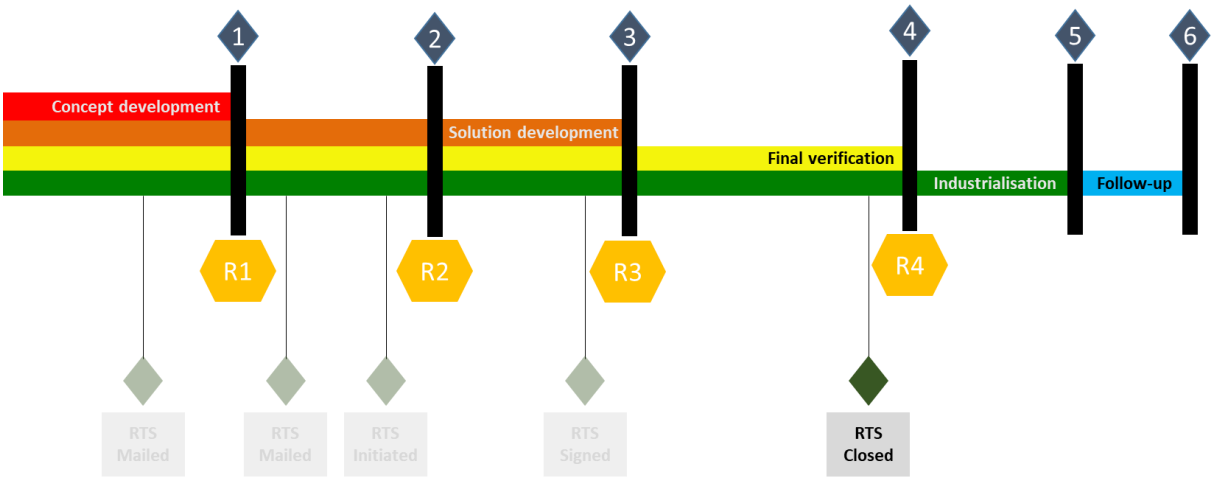

Figure 18 Timing of RTS Closed status

When the RTS has been used throughout the process, it holds extensive amounts of knowledge and experience. During the interviews, it was found that it is important for all stakeholders, and especially the SQEs, to fully commit to working cross-functionally to succeed with the difficult task of taking a part to serial production. The RTS is a great tool for facilitating this work and adds value throughout the process. This is one of the reasons it is included in the final PPAP documentation. The SQE can use it to see that issues connected to the technical documentation have been dealt with and ensure that when the part is ready for production, the process and part quality will be high.

4.2 PPAP in Projects

According to the interviews and observations, in addition to the descriptions of the generic time plan, this chapter further describes the activities that the SQE performs in a product development project. Between these stages, the SQE perform different activities such as, providing the sourcing board with the quality perspective for the supplier selection, among other things. The stages were studied via instructions and observed by the authors where the SQEs and managers described and demonstrated their work.

4.2.1 Concept & Solution Development Stages

In a project, the SQE is involved early in the product development process. Moreover, as earlier mentioned, when involved early the SQEs perform supplier evaluations prior to a supplier selection and they give input regarding quality aspects to the supplier selection done by a sourcing board. Prior to a selection, a supplier must answer a request for quotation (RFQ) that is sent to a number of potential suppliers for developing or/and producing a component for the OEM. As mentioned in chapter 4.1.3 Review of Technical Specifications, the RFQ contains the RTS that the SQE is responsible aiding the supplier in answering. Already in these stages, an estimated PPAP approval date is set by the project members, and some PPAP preparation from the SQE can be performed early as they need to work proactively. As part of being proactive, the RTS starts even prior the supplier selection, where the more effort is put early the less effort is needed when approving the PPAP. One key success factor in the initial stages is when the SQE is involved early, as they can then affect the project time plan but also easier plan their work prior the next coming stages together with their suppliers for the different components.

As mentioned in 4.1.1 Generic Time Plan, components for the OEMs products are classified into two distinct groups, components that are critical and non-critical. With critical components and where APQP reviews are done, the SQEs experience that the outcome is better when using APQP reviews than without, since some PPAP preparation is performed already early in the APQP. Furthermore, as mentioned in 4.1.1 Generic Time Plan, the APQP reviews are held at several occasions along the maturity in the development of the component and the SQE communicates both with the product development department, the buyers, and the project management to align the time plans and work tasks. To succeed with the collaboration, knowledge regarding what other individuals and departments contribute with and close collaboration is required. These factors are highly valued by the SQEs. Also, since the SQEs work as the interface between the OEM and its suppliers, they need to be able to communicate to build lasting networks with other individuals, to collaborate with the other departments and the suppliers.

4.2.2 Final Verification Stage

In a new product development project, as described in 4.1.1 Generic Time Plan, an order of a PPAP for a component is often triggered after the Solution Development stage and Release 3. Between the Final Verification stage and the Industrialisation stage, a lot of testing and verification is done by the OEM and supplier where the SQE is driving the supplier to succeed with the activities required for a PPAP approval. Success factors in this phase are to develop trust with the supplier and the other departments. Also, it is also important that everyone can communicate and collaborate with each other. Furthermore, when the, e.g. buyer and SQE are located with close proximity, it enhances their chances in communicating more effectively and efficiently. In this phase of the project, the SQEs express that they can quickly see the effects of their proactive work in preparing the PPAP with their suppliers from the initial stages.

4.2.3 Industrialisation Stage

When reaching the Industrialisation stage and the component's design reflects that it is ready for serial production. At this stage, as mentioned in the 4.1.2 PPAP Elements , the SQE require that all documents submitted from the supplier should be done and sent to the SQE two weeks before the PPAP approval date, to have time to check the documents. The SQE is responsible to give a PPAP approval and sign the Part Submission Warrant (PSW) submitted together with the required supporting documentation for the PPAP, depending on the decided submission level from the

supplier. In this phase, as mentioned in 4.1.2 PPAP Elements , the OEM requirement specifications that needs to be finalized, are also submitted. Since the SQE gives the final approval for a part to be used in serial production of the OEM's products, pressure is put from the organisation on the SQE to finish the big amount of PPAP approvals they need to manage. When the SQE receives the documentation, he/she checks that everything is completed in relation to the PPAP requirements.

When the PPAP approval has been granted, the serial production and shipment of parts can start. Moreover, this means that the component and the process used to manufacture these components are approved at the supplier's manufacturing site. Furthermore, if the SQE has a need to go through older PPAP documentation, the SQE requests the supplier to send it over since the supplier is obliged to store the documentation for the entire lifetime of the component plus one calendar year. Also, many SQEs see an opportunity in storing PPAP documentation in a web environment, where communication regarding the APQP/PPAP status, is transferred away from the email-based communication that is used today. Finally, the PPAP process followed at the OEM requires flexibility and customisation since the variety of components, requirements and size of the suppliers is big. Moreover, this means that the way of working with activities prior a PPAP approval must differ between the SQEs.

4.3 Identified Challenges

Under the course of the interviews with the SQEs, a number of challenges connected to PPAP were identified. The maturity of the technical documentation determines different actions needed for the SQE which are presented in the previous chapters. The identified challenges are presented in the stages where they have been mentioned during the interviews and where they impact the process the most according to the interviewees.

4.3.1 Identified Challenges – Concept & Solution Development Stages

During the interviews, it was noted that the SQEs role includes a high diversity of working tasks and that it involves a lot of travelling to suppliers. This results in the SQE having trouble staying informed with the projects´ progress and decisions, due to not being able to attend project meetings to the extent that would be preferable. This can result in issues with supplier collaboration according to the interviews. If the SQE is not involved early enough, the supplier does not receive essential information regarding the project which can result in delay down the line. It was also found that in some instances the SQE was not involved early in the process due to the project management not inviting them for project meetings initially. This was sometimes due to not seeing a need for involving them early and sometimes only because there was a lack of knowledge that the SQEs should be involved. This creates issues since it becomes difficult for the SQE to give input early and be proactive in the planning of the project. The SQE often has supplier specific knowledge which can be crucial for the success of a project and it is therefore important that they participate in the initial stages of planning. The SQE is also responsible for much of the supplier contact during the project time and it is therefore important to involve them early and to keep them up to date with the latest information.

Another finding from the interviews was that the SQEs possess a lot of knowledge that they accumulate over the years which is currently not passed on to the rest of the organisation. This was seen as an issue mainly due to the current way of working not focusing enough on knowledge sharing and lessons learned within the organisation and with the suppliers. It was also noted that sharing knowledge and experiences with suppliers enables for closer collaboration and in the end better results for the PPAP and developed component. The knowledge from previous projects can

also be utilized when starting new projects and, in that way, mitigate reoccurring challenges. It was also pointed out that this knowledge is often lost when an SQE leaves the organisation due to the tacit knowledge being left in the minds of the SQEs. This creates large issues for new employees taking over suppliers due to the history and learning from that supplier is lost.

The lack of knowledge sharing can also be connected to the process being hard to understand for new employees and suppliers. As previously mentioned, there is a need for the process to be flexible to accommodate many different types of part and types of suppliers. However, certain steps in the process were deemed unclear according to the interviews. One example of this is the fact that the storage of documentation connected to the PPAP is not clearly specified in the instructions available to the organisation and the supplier. The instructions can be interpreted in different ways which creates many questions which is seen as waste. Furthermore, the fact that the organisation currently does not store any PPAP documentation was seen as challenge by interviewees. This becomes a problem when documents are needed, for instance, to see what has been done before with the same supplier.

Several interviewees also point to the fact that it is hard to give critical feedback internally especially in the initial stages where input material has a significant impact on the project. This was linked to a lack of communication and trust between the departments. The interviewees also connected this to the previous mentioned point that there is a lack of knowledge about what is important for other roles. It was also stated that the different departments do not see that they are all trying to achieve the same end goal, the goal of delivering a high-quality product for the end customer.

4.3.2 Identified Challenges – Final Verification Stage

When the project has moved forward to the Final Verification stage, as show in Figure 10, the SQE start getting more active with the PPAP and the workload increases. According to the interviews, it is often at this stage they face issues with tracking activities connected to their suppliers. This is especially true if the SQE is responsible for many components in development and at the same time is responsible for maintenance activities, like audits, with suppliers. Currently, the SQEs must take individual initiatives to track their activities with personal excel files. This has also been a frequently mentioned issue from the interviews, that there is no common system for planning and following-up the PPAPs currently in the pipeline. This creates issues since the organisation cannot monitor and follow-up the active PPAPs in a straightforward and transparent way. This leads to missed activities, delays, document and drawing versions not being correct which in the end makes it hard to efficiently collaborate with the supplier.

In the third stage, the goal is to have the design fixed and the part only needing minor modifications to be completed. However, during the interviews it was found that there are often late changes in the design after the Final Verification stage. This makes it hard for the SQE to communicate efficiently with the supplier and the work of creating a solid plan for PPAP approval becomes harder. The SQEs coordinate with the suppliers to make sure, that the agreed date for PPAP approval can be met, or if changes in the time plans are needed. If changes are late or not properly communicated it can break the planning and create the need for rework. Many of the interviewees connect this to issues with the collaboration interdepartmentally. An example of this, that was mentioned at various occasions during the interviews, was that parts can move through stages, or skip stages, even if the maturity of the part is low. This means that the SQE gets even less time to assure that the quality of the part is good enough for production which makes the job difficult. One of the main reasons for this is, according to several SQEs, that the different departments work in silos and there is poor knowledge about what the other colleagues are doing.

This creates issues when trying to collaborate and understand each other. Because the different departments have little understanding of each other's roles and they are not viewing the process as something they are doing together. Furthermore, this increases the issues with collaboration and communication.

When discussing communication in the interviews, several challenges were found connected to both external and internal communication. As mentioned earlier, internal communication is lacking between departments involved in PPAP. The main issue this creates is when changes and decisions are not properly communicated which leaves the SQE and supplier in the dark. One example of this is when a design change is not communicated to the SQE and supplier which create double the amount of work and time waste. This can be connected to the previous identified challenge of not having an IT system to track and monitor the PPAP for both the external and internal stakeholders. One of the key issues that the OEM is facing, according to the interviewees, is that the lack of system support makes it hard to keep track of the communication with the suppliers.

Sometimes communication and information exchange occur between PD and supplier without the SQE knowing. The interviewees stress that this creates issues because the SQE can have obsolete technical documentation regarding a component when trying to finish a PPAP. One interesting aspect mentioned during the interviews was that many of the process used in within the department comes from the time when physical documents where sent over by mail or fax. This meant that documentation and communication were available physically in the organisation. With the implementation of email, the communication has become quicker but harder to track since it is the individual SQE, buyer or PD who has the communication and documents locked in their computer. This becomes an issue when staff quit or moves to another department because the communication with the supplier is then lost. As mentioned previously, this can be connected to the lack of sharing knowledge within the organisation and with the suppliers.

4.3.3 Identified Challenges – Industrialisation Stage

When the project/part has gone through to the Industrialisation stage, it should be largely ready for use in serial production. This is also the stage when the SQEs need to work hard to get the finalised documentation from the suppliers to holistically evaluate the quality of the part and the production process. During the interviews, it was found that the SQEs see this work as time consuming and administrative since they need to chase after documents to a large extent. When the SQEs do receive the documentation, the delivery is often fragmented and hard to follow. This was deemed to be a challenge which was especially prevalent with new suppliers who had not worked with the OEM before. This wastes time since the SQE needs to go through each document to find specific data-points. This was also mentioned in connection to the lacking system support for the PPAP.

As mentioned in the Final Verification stage, there is currently no system for tracking and following-up on PPAPs which is seen as a challenge. The SQEs have stated that a system, where the suppliers and internal stakeholders have access, would help the administrative burden since they could then stop chasing after documentation and information connected to a part. This would also alleviate the previously mentioned challenge of not having easy access to the PPAP documentation after completion. By not having control and access to the documents creates a greater risk according to the interviewees since the supplier can, in the event of a conflict, easily modify the previous documentation to protect themselves. Hence, this points to the storage of documents not only being an issue for the individual SQE but also on an organisational strategic level.

The interviewees further described that when working with the PPAP they often meet a low level of knowledge regarding what the PPAP actually is from both internal and external sources. It was found that other departments and suppliers have a general lack of knowledge regarding PPAP. Most interviewees agree that other internal functions often think that the PPAP is only a paper to be signed and do not understand the amount of work that feeds in to an approved PPAP. This connects to the previous mentioned points about the functions at the OEM working in silos. This is however not only a challenge internally; it is also connected to the suppliers. It was found that it is often the case that a supplier does not fully understand what is needed from them to successfully introduce a part to serial production and product application. Furthermore, the supplier is often not aware of the extent of requirements the OEM has on components and processes which often leads to delays. It was also shown that the suppliers do not fully understand the importance that the information is sent to the SQE in good time. This also causes delays in the process and time waste for the SQEs chasing the supplier for the right documentation.

When the PPAP is close to being finalised the SQEs start facing issues because the stakeholders involved in the process cannot see the status of the PPAP on a granular level. According to the interviews, this is an issue since the SQE needs to spend time updating stakeholders about the status and explain the actions needed to complete the PPAP. It is often the case that the actions that are needed to bring the PPAP forward is not the SQE's responsibility, but that is not understood or seen by the other stakeholders. This was discussed in connection to the fact that there is no system in place to get the full picture of the project details and progress as mentioned previously. During the interviews, it was suggested that a system, where SQE, buyer, PD and supplier had access, would save a lot of time. It would remove the need for the SQE to update different stakeholders about the status of the PPAP, create more transparency and in the end, save time. This is also an issue because the SQEs are the last player in the development process, as they are the ones responsible for approving a component for serial production, throughout PPAP. If there is a delay in the end, the SQE will often be blamed, even though delays have occurred due to factors outside the SQE's control. This creates a lot of extra work when explaining what has happened and why to other stakeholders. Many of the interviewees stated that even if the delay is not due to them, they still get most of the blame when a project is delayed.

Delays were also often mentioned during the interviews as a challenge that the SQEs face when working with PPAP. The interviewees describe how the timeline of the project is often pushed to its limit and that early delays do not translate to a changed date for the final approval. This creates friction between the SQE and the supplier in planning due to them having fixed lead times for tooling and testing. This means that you must plan for an interim PPAP, a deviation, instead for the complete approval which is seen as counter intuitive. Furthermore, down the line, this creates issues with who is responsible and has ownership for the interim status. According to the interviews, it is often unclear who from the organisation that has responsibility for some deviations. This was mention in relation to technical documentation and drawings that need to be updated as well as environmental information. Furthermore, it is unclear who should communicate and solve issues related to these deviations together with the supplier.

5 Analysis & Recommendations

In this chapter, an analysis of the empirical findings and related recommendations will be presented. The analysis presents formed groups for the different challenges followed by an interrelation diagram to illustrate the connection between the groups. The analysis part will finish with a discussion for the prioritised areas for this thesis. Finally, for the prioritised areas, recommendations for SQD will be presented. The aim of this chapter is to answer research question three.

RQ3

What recommendations should be considered in order to mitigate the key challenges faced in connection to PPAP?

5.1 Analysis of Challenges

In this section, the analysis of the findings will be described. For the analysis and the grouping of the different challenges, mentioned in the empirical findings, the methodology of the Affinity Diagram was used, described in 3.4 Analysis of Data.

5.1.1 Knowledge Sharing

When analysing the findings from the extensive interview program, using the affinity diagram, the first identified theme was Knowledge Sharing illustrated in Figure 19 below. The SQEs explained during the interviews that there is a general silo mentality when working with the PPAP. This could be connected to the fact that knowledge and information was not easily shared between the different functions or with the suppliers. Another factor connected to this was a general lack of knowledge regarding the different roles and their responsibilities involved in the PPAP. The SQEs frequently mentioned that the understanding of what a PPAP is and the work that is needed to complete it was not understood by the other functions. This was exemplified with situations where the SQEs get blamed for delays in projects when they were not at fault. Furthermore, the supplier's knowledge about the process was described as low which in turn connects to a lack of knowledge being shared between the OEM and supplier.

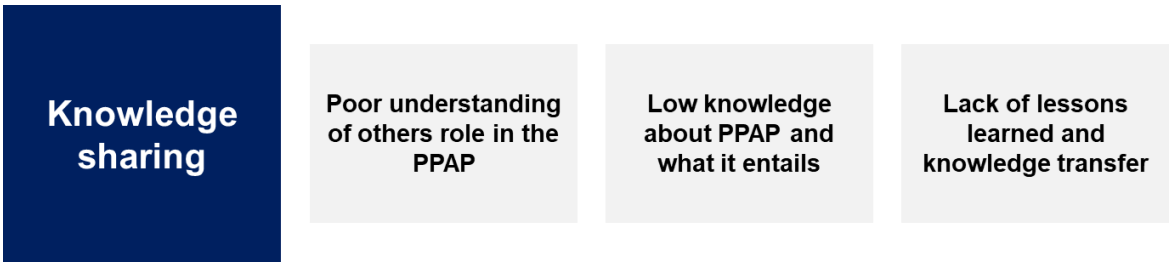

Figure 19 Affinity diagram - Knowledge sharing

Another factor that can be associated with knowledge sharing was the lack of focus being put on lessons learned within the process. From the interviews, it was seen that much of the knowledge that was gathered during projects was not codified and left in the minds of the SQEs and other project members. There are systems and processes in place to capture these things, but they are not seen as value adding by the SQEs and they feel that they do not have the time to participate in

the current state. The lack of knowledge sharing also translates to the process being hard to understand for new SQEs and new suppliers.

As Ameri & Dutta (2005) explains, knowledge management and transfer is essential to achieve market success where other researchers also have seen the importance to identify, share and capture knowledge and skills in an organisation to further stay competitive. Hence, for the challenges the OEM is facing with lack of knowledge sharing, it is important that the OEM capture and share knowledge internally and with their suppliers to succeed in the product development through PPAP. The knowledge captured in the OEM's projects can be used or re-used to enhance the project for new product development as described by Cantamessa, Montagna, & Neirotti (2012). Furthermore, as Darawong (2015) explains, that knowledge transfer can be affected by communication in a positive way. Moreover, by letting departments effectively and efficiently communicate with other departments it might enhance knowledge sharing. To transfer knowledge within the OEM's organisation and with the suppliers, to break down the barriers between the departments, the OEM can together solve different problems together, cross-functionally and make sure that everyone understands each other's work and responsibilities. These methods are supported by Malamed (2017) and Hermans (2013). Since the experienced SQEs carry a lot of tacit knowledge that is not shared with the rest of the network, it is important that they share this knowledge and make the knowledge explicit to the organisation and their suppliers. The importance of making tacit knowledge available to the organisation and the network at the OEM is supported in the theory by Ameri and Dutta (2005) and Kmetz (2012).

5.1.2 External & Internal Communication

The second theme that was identified, using the affinity diagram, was *External & internal communication* as shown in Figure 20. As mentioned in the empirical findings, there are many challenges connected to communication, and the lack there of, in connection to PPAP. Issues with external communication were frequently mentioned during the interviews. This was mostly connected to not being able to track communication between SQEs, PDs, buyers, and supplier. The main pain point in this area was the fact that most communication is managed through email which is connected to individual employees. This individual communication could also be linked to difficulties in knowing what has been communicated from other departments. SQEs exemplify this by pointing to design changes that they were unaware of due to them not being included in the communication when changes were sent to the supplier. This also points to internal communication issues which are a frequent occurrence according to the interviews. Moreover, the fact that it is hard to provide feedback internally in an effective way when it comes to material from other departments is also linked to communication. Several SQEs mention this, and that it creates issues down the line with supplier cooperation. This was mostly connected to work done in the initial design stages of development that the SQEs use later in the work with PPAP. Using input material that is not specified enough can create ripple effects which can have significant impact on project performance, and it is therefore important to put high demands on internal as well as external deliveries.

Based on the OEMs challenges with internal and external communication and the literature's emphasis on this area makes it an interesting topic to further investigate. Hung, Kuo & Dong (2013), state that both internal and external communication is important in a supplier/buyer relationship for high performance. Furthermore, the authors stress that communication should be frequent and cross-functional. The interviews showed that a key success factor for PPAP is close collaboration with both internal and external stakeholders which is supported by the author. McIvor, Humphreys & Cadden (2006) points out that it is especially important to have close communication with suppliers. The OEM's current challenges connect to this fact by not

communicating valuable information with suppliers and internally. The authors further explain that this should be taken into consideration since it is important to share the right information at the right time. This is also supported by Wheelwright & Clark (1992) who elaborate on the importance of communication in product development.

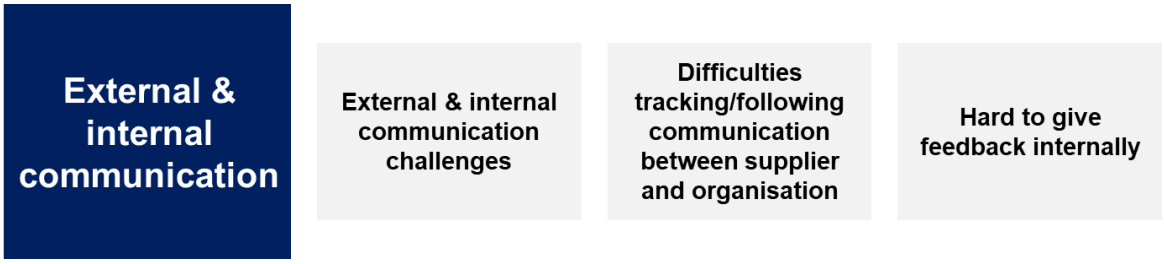

Figure 20 Affinity diagram - External & internal communication

Since the work of finalising a PPAP is a collaborative task, it is important to not only focus on communicating, but how also how you communicate. Wheelwright & Clark's (1992) model of downstream and upstream communication highlights the challenges at the OEM well. The model showcases that communication should happen early and frequently to ensure high performance when collaborating. The challenges the OEM are facing can be connected to the two first modes described in the model, "Serial/Batch mode" and "Early start in the dark". These modes have communication patterns that start too late, is infrequent, and of lower quality. One of the key issues within the OEM is that the communication is not transparent and not seen by other functions which support the connection to Mode 1 and Mode 2, explained in 2.3.2 Communication.

5.1.3 Collaboration Between Stakeholders

The third theme identified from the affinity diagram was *Collaboration between stakeholders*, as shown in Figure 21. As described in the empirical findings, the SQEs experience that the collaboration varies between departments in projects. They point out that the performance of the project depends on factors such as, individuals´ capability to collaborate but also that physical distance to each other can affect their team performance. Furthermore, as part of collaborating, the SQEs are not always involved early enough in the projects to give input on planning and to be able to work proactively in the initial stages of the product development. For the SQEs, it is very important to align the project time plan with the supplier. This time plan is frequently changed due to design alterations after the third design release, R3, which increases the effort needed from the SQE in the planning and finalisation of PPAP. Also, the project performance is dependent on the supplier performance, which also varies from case to case. In the end, this leads to, the project participants facing issues in projects due to unclear roles, responsibilities, and poor overall collaboration internally and with suppliers. As described, the common factor for these challenges are overall collaboration.

Figure 21 Affinity diagram - Collaboration between stakeholders

As described by Wheelwright & Clark (1992), collaboration and communication between downstream and upstream groups in a value chain should start early and the collaboration must be close, where information is shared frequent. This will enable the upstream and downstream groups to have a "flying" start and an understanding of each other's challenges and constraints will easier be considered when developing a new product. At the OEM the departments face issues with not collaboration well enough together with both their suppliers and with each other. Therefore, with upstream and downstream groups as described by Wheelwright & Clark (1992), it is important to involve the supplier and the SQE at an early stage in the project to successfully plan and anticipate risks in the project further on. When involving the supplier early in the product development it is important for the SQE to align the supplier time plan with project time plan. This will make sure that the supplier follows the project lead time. For the collaboration to function between the OEM and supplier, it is important that the supplier, no matter if the component is critical or not, follows an APQP. As AIAG (2019) explains, by following an APQP, it helps reducing the complexity of product planning between suppliers and customers, in this case the OEM. In order for the OEM to collaborate within the organisation but also externally, it is important that the employees participate and work together in social networks, as supported by Laycock (2005).

5.1.4 High Administrative Workload

The fourth theme that was identified during the analysis was that the SQEs face a *high administrative workload*, depicted in Figure 22. From the interviews there was a common discontent with the current process because a lot of time was spent chasing after documentation. This in connection to the role of the SQE which includes lots of traveling to suppliers, was deemed a challenge by many. The administrative work was made worse by not having a standardised way of receiving the PPAP documentation from the supplier. They are often sent in fragmented batches over email with no clear document naming, making it hard for the SQE to read out what the document actually is. This further adds to the administrative burden when having to scan through documentation without a clear structure.

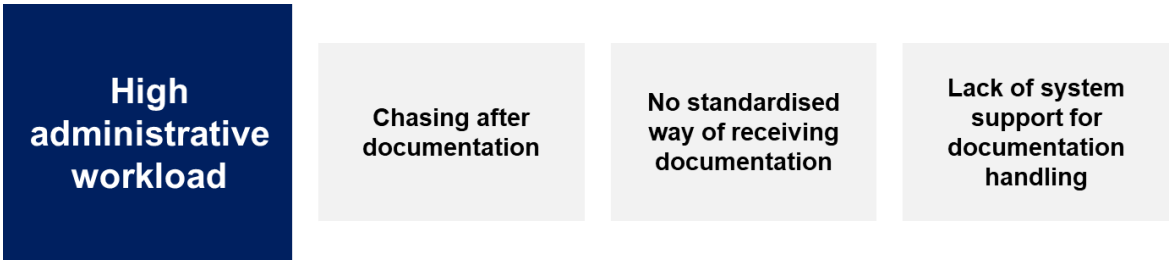

Figure 22 Affinity diagram - High administrative workload

Another aspect of this that can be linked to the high administrative workload is the lack of system support in connection to PPAP. This makes it hard for the SQEs to keep track of activities and manage the incoming documents in a straightforward way. When historical documentation is needed this also puts a strain on the SQEs since they need to go to the supplier and ask for it. This was seen as cumbersome by the SQEs and was deemed to increase the administrative burden.

All processes in an organisation should, according to Dewey (2019), be aimed at increasing the value for end customers. PPAP documentation handling was deemed to be administrative, and it is an example of when the employees do not see the added value for the end customer. This in turn leads to reduced performance connected to the collaboration with suppliers. It is common that administrative processes deteriorate over time which leads to non-standard activities and workaround being used to get around the processes (Holweg, Davies, & Meyer, 2018). This

highlights the importance of reduce the administrative workload, to enable the SQEs to spend more time on actions that directly adds value to the end customers.

Furthermore, the administrative burden was worsened by the fact there was no IT system support available for the PPAP according to the SQEs. This can be linked to Vukšić, Brkić, & Tomičić-Pupek (2018) who state that sufficient IT system support is a key success factor for Business Process Management. However, an important factor to keep in mind when implementing an IT system is to align it with the process and the envisioned way of working (Tirkman, 2010).

5.2 Cause and Effect Analysis & Focus Areas

In order to prioritise and find the theme with the most impact on the current way of working with PPAP the interrelationship diagram was used as described in chapter 3.4 Analysis of Data. The purpose of this analysis was to find which of the themes were main drives to the challenges currently faced at the OEM. The finalised interrelationship diagram is presented in Figure 23 below.

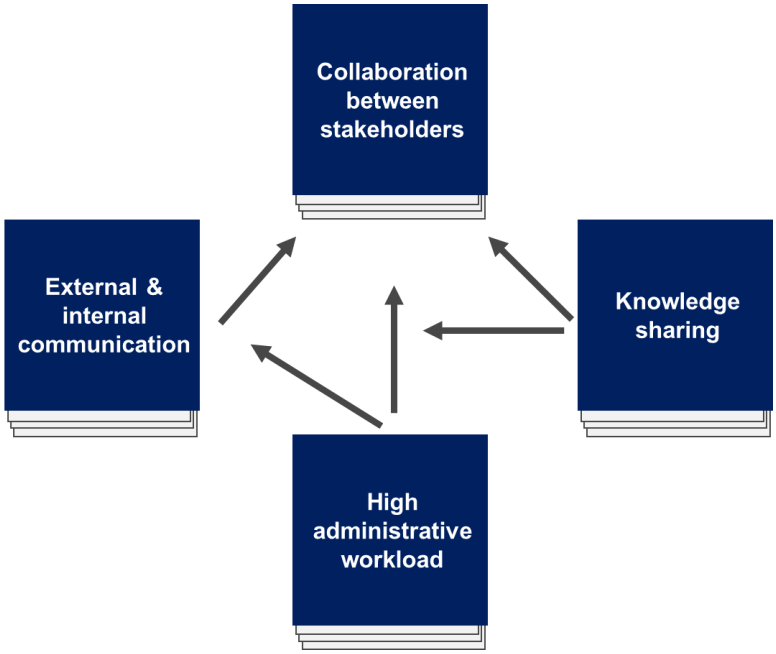

Figure 23 Finalised interrelationship diagram

The analysis indicated that the basis of many of the challenges, identified during the interviews, were connected to a lack of knowledge sharing with the suppliers and within the organisation. Both the themes, Collaboration between stakeholders and External & internal communication where deemed to be caused by a lack of knowledge sharing. Firstly, the collaboration challenges were most often connected to a lack of knowledge from other stakeholders involved in the PPAP. This was, as mentioned previously, connected to poor knowledge about the roles of the other stakeholders and their responsibilities. Furthermore, the collaboration suffered because of lacking supplier knowledge which the OEM should have provided the supplier with to ensure project success. A clear example of this was when the process expectations from the OEM was not clearly understood by suppliers.

Secondly, knowledge sharing also greatly affected internal and external communication at the OEM. When discussing communication, both internal and external, many of the challenges could be connected to poor knowledge sharing. One fact that was apparent was that knowledge that

exists in the minds of the SQEs was not shared. This was seen as a cause of the lacking communication between the OEM and suppliers but also internally. The knowledge the SQEs gain through their contact and collaboration with a variety of suppliers can be used to further improve the process. It can also ensure that issues faced in the past are communicated and mitigate early on both with the supplier and between departments. Moreover, not knowing who to communicate with is also a factor mention in connection to the communication challenges. By not having the correct knowledge about stakeholder responsibilities, time is wasted in the product development process and for PPAP approval. Also, as mentioned previously, the version of documents sent is not always communicated to the SQE which was deemed to be caused by a knowledge gap in the organisation. The responsible parties simple do not know how important it is for the SQE to have this information and do not take adequate steps to inform them.

By not having the correct information or documentation is an issue that is directly connected to the administrative workload of SQEs. One of the major factors in the challenges faced with the administrative workload is the lack of system support for the process. This makes it hard for the SQE to keep track of the documentation sent between the organisation and the supplier. It also makes it hard for the SQE to efficiently communicate with the supplier and other stakeholders. This in turn, affects collaboration between the different departments and suppliers due to disagreements connected to what has been said and sent. Furthermore, the systems currently in place are not transparent and not all stakeholders have access to all the information. This leads to poor communication and in the end, it negatively affects the collaboration between all stakeholders.

In addition to the interrelationship diagram, the identified challenges were counted, as explained in 3.4 Analysis of Data, to further strengthen the analysis. The results from the quantification of the challenges are presented below in Figure 24. As shown in the graph, *Knowledge sharing* is the theme with most mentions. This in connection with it being a main driver, as seen in the interrelationship diagram above, shows that focusing on this when moving forward will most likely generate a significant impact. The second driver identified in the interrelationship diagram was High administrative workload. When looking at the quantification it is not mentioned as much as the *External & internal communication* and *Collaboration between stakeholders,* but it is seen as a cause of both these themes it is still relevant to focus on moving forward. Further data from the quantification of challenges can be found in Appendix D – Quantification of Challenges.

Based on the above-mentioned aspects, the most pressing areas to address were deemed to be Knowledge Sharing and High administrative workload. The recommendations presented in the next chapter are therefore focused mainly on addressing them.

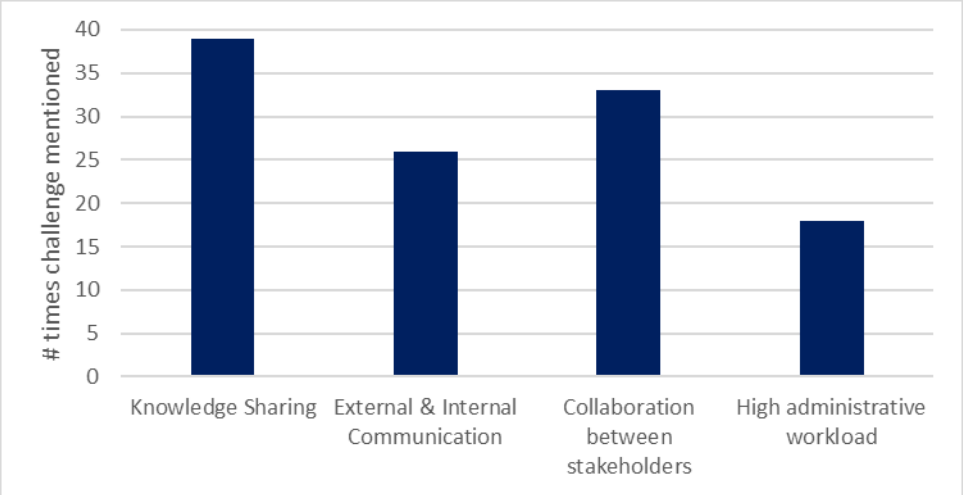

Figure 24 Quantification of challenges

5.3 Recommendations

As the analysis clearly points out, the underlying drivers for the challenges at the large OEM with the PPAP are Knowledge Sharing and Administrative Workload. This was concluded by looking at the underlying drivers for both the challenges connected to communication and collaboration. The aim of this chapter is to address the selected focus areas with suggestions on how the OEM can improve the current situation and increase their PPAP outcome and performance.

The study was conducted with the aim of getting a holistic view of the work with the PPAP at the OEM which is needed to understand what can be done to improve it. When looking at a process, the BPM literature stresses the fact that the process needs to be understood on a high level to see how it interacts with the other parts of the organisation (Hammer, 2015; Dumas, La Rosa, Mendling, & Reijers, 2013). Furthermore, the study was aimed at creating a thorough understating of the current state before suggesting improvements which is well supported in the literature. (Holweg, Davies, & Meyer, 2018; Andersen, 2007; Eileen & Scott, 1995; King, King, & Davis, 2014).

The following recommendations are focused around improving knowledge sharing and administration which is believed to further mitigate the communication and collaboration challenges the company is currently facing. This is supported by Vukšić, Brkić, & Tomičić-Pupek (2018), who state that key success factors for efficient BPM is increased communication and interdepartmental collaboration. When addressing these key success factors the goal is to create long term performance increases through incremental process improvements. Eileen & Scott (1995) and Davies and Meyer (2018) both point to this being suitable for the kind of challenges identified throughout this thesis.

The improvement recommendations can be viewed through the seven steps presented in chapter 2.1.1 Process Improvement created by Andersen (2007). Using this as a guide, this study has gone through the first 5 steps, Prioritising areas, As-is analysis, Data collection, Data analysis, and finally brainstorming improvement suggestions. The end goal is for the OEM to use these recommendations as a guide when moving forward in creating lasting change. The last two steps of Andersen's (2007) model are, further develop improvement suggestions and lastly implement them. This study can be used as a reference when selecting improvement actions and implementing them at the OEM.

Below the recommendations that form the basis for answering Research Question 3 is presented in a short term and medium-term timeframe.

5.3.1 Short Term - Focus on Improving Knowledge Sharing Internally and Externally

The following section describes the recommendation for the OEM in a shorter term, to support in answering RQ3: *What recommendations should be considered in order to mitigate the key challenges currently faced in connection to PPAP*. The initial recommendation for the OEM, in a short term, is to focus on increasing and improving knowledge sharing both internally but also externally. Moreover, a more detailed explanation of each recommendation can be found below.

Use cross-functional education to enhance knowledge sharing with suppliers and in the organisation

The first recommendation is to focus on knowledge sharing together and among the different departments at the OEM and with its suppliers, as this should be done in several steps. The supplier quality department (SQD) at the OEM is planning a rollout of APQP education with the primary focus on the internal organisation with the purchasing, product development and project management departments. The aim of this education is to enlighten everyone within the OEM about the fundamentals of the APQP process and it will focus on the importance of the generic time plan between all the stakeholders in a project. The first step in this education is to enlighten the purchasing department and the buyers within, about the mind-set in APQP. SQD argue that it is most important that the buyers get educated first since the SQEs and buyers collaborate closely in their work tasks with the suppliers. This will be the first step to increase knowledge and awareness. Furthermore, the recommended next step is to expand the scope of the APQP education and conduct additional education about PPAP. The OEM should, similar to the APQP education, also educate the purchasing, product development and project management departments. Moreover, this could solve the challenges with low PPAP knowledge, where the SQE gets pushed to PPAP approve a component that still has open risks. In this step, to succeed with these education sessions, the material should have a clear link to PPAP and explain the building blocks to get a PPAP approval. It is important to highlight that the whole organisation together with the suppliers, are responsible for a PPAP approval and that it is not only the SQE who is responsible for it in the end. Therefore, it is important to highlight the different roles in a project to create a mutual understanding. Moreover, this could also solve the issues the SQEs are facing today when getting blamed for delayed PPAPs, as described in *5.1.1 Knowledge Sharing*.

Furthermore, for the participant to understand the different roles in the organisation, the education material should include activities to highlight and enhance the understanding of the different roles in a project. This can in return lead to an understanding to include the SQE and supplier early in the product development process, where they in the current state are not always involved early enough. Also, it will decrease the work with silo mentality as employees might recognise and accept each other. When organising the teams in the education sessions, it will be essential to have one member from each department within the OEM to engage the members in cross-functional problem solving and knowledge sharing. In these cross-functional teams, the OEM should include knowledge sharing practices where the participant can discuss/solve a case and share their expertise related to the matter.

When the education for internal purpose has been conducted, the recommendation is to try involving the suppliers in APQP and PPAP education that can improve the communication and collaboration between the OEM and suppliers. The first step for this recommendation is to create

basic knowledge in these processes at the OEM. This can be conducted by animated educational videos, similar to the ones used internally at the OEM today. In this step, it is important to highlight that the suppliers deliver the right information to the OEM, at the right time. Furthermore, the OEM should highlight the importance of sharing knowledge between the supplier and OEM, as it benefits both parts when creating long-lasting partnerships. When basic knowledge has been created, this will enable the SQEs to easier educate the suppliers when they are visiting the suppliers' manufacturing sites. The envisioned results with these educational recommendations are to enhance knowledge about the colleagues from other departments, where everyone believe that they are a part of an approved PPAP. Furthermore, the recommendation regarding supplier education can enable the supplier to understand their role in the product development where they strive to deliver the right information at the right time to the OEM.

Improving existing Knowledge Sharing Forums for the suppler quality department

In addition to the proposed educations, there is an online knowledge sharing forum that exists today within SQD but is not used to its full potential. As described by Malamed (2017), online social networking is an effective way to transform tacit knowledge into explicit. Therefore, the next recommendation, which the OEM can do in short term, is to utilize the existing knowledge management forum to share more knowledge between SQEs. In the current state, the OEM uses a web-based system for knowledge management, where they have meetings to discuss different topics uploaded in the system. In this system, the employees within SQD can share best practices and learn from previous experiences from each other. In the current state, the activity in this system is deemed rather low and only a handful of employees contribute to this forum. To enhance this knowledge sharing, there is a need to increase the meeting frequency for knowledge management and let employees take time to contribute to the forum. Furthermore, to increase the knowledge sharing there is a need to increase the incitements and make it easier to share knowledge. This can be done by encouraging all SQEs to upload material with best practices that they might possess. Since the SQE shares a lot of knowledge with the suppliers and they get a lot of insight in the supplier processes from visiting the supplier sites, this knowledge can be essential to the rest of the OEM organisation. By sharing this knowledge in an open forum, new SQEs can quickly pick up valuable knowledge and easier understand their work processes. In addition to new SQEs, new Buyers could easily get introduced to the supplier quality processes by providing them, as part of their introduction program, informative meetings with the SQEs.

In order to create incitements to change into a more knowledge sharing organisation, Nadler & Tushman´s model for change, mentioned in 2.2 Change Management, is useful. For an SQE to voluntarily share knowledge in the forum, there will be a need to get support for sharing knowledge from key power groups such as managers. Furthermore, the initiative to share knowledge needs to come top-down, where the managers support the SQEs to share their knowledge with each other by providing a framework. The procedure on how to share knowledge should come from the employees, bottom-up. To do this, managers can use symbols to provide a clear message of how important knowledge sharing is and what it can result in. Also, to increase knowledge sharing, the managers should use procedures to create dissatisfaction with the current state, where real cases are visualised of the consequences with low or non-existent knowledge sharing and success stories of high knowledge sharing. It will important for the management to involve the SQEs in setting up knowledge sharing sessions, where the SQEs can be responsible to plan and contribute in the knowledge management forum. Furthermore, by letting SQEs discuss their own topics to share during knowledge management meetings, this will make them feel more involved. According to Nadler & Tushman (1997), these are ways to mitigate resistance and anxiety related to change and to create political dynamics.

The knowledge sharing during the meetings can be done by a method called downloading as described by IDEO (Design Kit, 2019). In this method, when a sufficient number of notes have been provided by the team related to a topic and prior the meeting, they can together make sense of the material and download their findings as groups. Preferably, SQEs should facilitate the downloading session to create high involvement and responsibility from the employees. When using this method, the members of SQD should one by one capture stories on post-its and attach them to sheets of paper. It is essential that every participant pay close attention to the other teammates when they share their stories and learnings as well as hunches. In the end, this will enable the OEM to transform others´ individual learnings into collective group knowledge. The goal for the OEM should be to make knowledge sharing a daily work practice that may affect the organisation in a positive way where processes can continuously be improved.

5.3.2 Medium Term – Conduct an External Study and Implement IT System

This section will provide the OEM with recommendations in a medium term. For the OEM to successfully implement an IT system for documentation storage and suppler communication and in addition to this thesis, there is a need to conduct an external study, taking the supplier perspective into account. A further description of the recommendations is displayed below.

Conduct an external study – Supplier's perspective

To implement system support for, e.g. PPAP documentation and plan follow-ups, there is a need to first consider the supplier needs. Both the OEM and the supplier will be customers to an IT system and therefore it is important to take both the perspectives into account before an implementation can be conducted. As described in 2.1 Business Process Management, it is important for the OEM to take into consideration the fit between the APQP/PPAP process characteristics and the capabilities of the IT system. The IT system must match the needs of the SQE/Supplier and the activities that they conduct, else the system will, in the end, not be adopted. Therefore, it is crucial for the OEM to identify the needs of the suppliers and what they require when using an IT system. Furthermore, if other departments than SQD are to use the system, it will be crucial to find these needs as well. Therefore, the recommendation is to find the needs of the external customers to SQD by conducting a similar study in comparison to this thesis. For this recommendation, the OEM should consider including five large and five smaller suppliers for interviews, to capture as many needs as possible and find similarities/differences. It will be crucial for the OEM to find out about the challenges that these suppliers are facing but also their best practices, since they often work for other large OEMs as well. Moreover, the collaboration with these other OEMs might be better in comparison to the OEM studied in this thesis. Therefore, it is important to know how these collaborations work, where the OEM can find inspiration from these. Finally, when the study has been conducted, the OEM should have enough of data about needs of an IT system, to consider implementing an IT system for PPAP/APQP planning and documentation storage. To keep in mind is that the findings from the suppliers can be a major source of information and knowledge that could be used to improve other processes as well.

Implement IT System Support

When the needs of the supplier have been addressed and by taking this thesis´ findings into account, the following recommendation is to involve a team of experts in the subject of IT-Management to evaluate an IT system implementation. This team should evaluate the system needs of the organisation from a SQE, PD, PM, Buyer, and supplier perspective. The IT system should encompass the entire process from when the first material related to a new component is created by the OEM and the supplier. Therefore, the system should be able to communicate with

the newly implemented SAP system and preferably other internal system within the OEM. As mentioned, the challenges identified from the empirical findings in this thesis should be used as a guide for the needs to be considered from SQD. Furthermore, the system should be able to store important PPAP and APQP documentation, where suppliers and the OEM can communicate with each other to track communication and agreements. By having a transparent communication channel, the OEM and supplier will be able to decrease product development and PPAP risks. Also, it will mitigate the risk of losing valuable information and documentation from the supplier in case an SQE is absent or quits their job. By using an IT system for communication and documentation storage, it will make sure that everyone knows what has been sent between the supplier and OEM in which mitigates the risk when the OEM does not know what has been sent between the two parts. Furthermore, the IT system should decrease the administrative work burden by letting the supplier and OEM use electronic signatures and transfer the communication from email based into the IT system. All in all, it will be essential to get a holistic view of the process and people who perform their work in it to successfully implement a system that will be accepted, used, and adopted. To keep in mind is, what cannot be designed away, i.e. done by the IT system, should be mitigated by new process steps and changes. In the end, the envisioned results will be to have an IT system for PPAP/APQP documentation and follow-ups that is easy to use for the SQEs and suppliers which is also transparent to the other departments within the OEM.

6 Conclusion and Discussion

In this chapter, the conclusion of the thesis is presented which connects to the research questions answered in chapter 5 Analysis & Recommendations. Furthermore, interesting topics for further research is discussed.

6.1 Conclusions

The purpose of this thesis was to evaluate the how the supplier quality department at a large OEM works with PPAP and give recommendations on what areas they should focus on to improve the process. To study this topic and breakdown the study in manageable parts, three research questions were developed and subsequently answered.

The first research question – *How do the SQEs work interdepartmentally and with their suppliers in order to approve a PPAP?* was answered in chapter 4.1 PPAP at the OEM and 4.2 PPAP in Projects by going into detail on how the SQEs work in each step of the PPAP. The aim of this questions was to create an understanding of how the SQEs work with the process today to function as a basis for further evaluation. The main conclusion that can be drawn from the findings connected to the first research question is that the way of working is very individual and complex. This is a consequence of the highly variable nature of components and the need to customise the work based on the requirements of each component. The way of working is also characterised by cross-functional activities that require frequent communication to succeed. Furthermore, it is the conclusion of this thesis that the process should have room for flexibility. This is to ensure that standards do not hinder the SQE from adapting the process to the individual part and supplier.

The second research question - *What challenges are the SQEs facing when working towards a PPAP approval in collaboration with suppliers and interdepartmentally?* was answered in chapter 4.3 Identified Challenges by outlining the findings from the extensive interview program conducted at the OEM. By working systematically to identify challenges in each step of the process of the individual SQE, the overall theme of challenges the SQE faces was then presented in chapter 5.1 Analysis of Challenges.

The findings and analysis point towards the conclusion that when collaborating with a large supplier network in a global setting, challenges connected to knowledge transfer, administrative work, communication, and collaboration make a significant difference. A conclusion that can be drawn from this is that it is crucial for the organisation to share knowledge between departments and with suppliers. This is a prerequisite to ensure efficient and highly productive collaboration between internal and external stakeholder. Moreover, another conclusion to be drawn is how knowledge transfer impacts overall collaboration and communication. This was shown to have a substantial impact on both internal and external cooperation and communication capabilities for the OEM.

The third research question - *What recommendations should be considered in order to mitigate the key challenges currently faced in connection to PPAP?* was answered in chapter 5.3 Recommendations. The recommendations presented in this chapter connect directly to the purpose of the thesis which states that the end goal is to provide the OEM with recommendations going forward. The main focus behind the recommendations was to mitigate the challenges identified earlier which are connected to communication, collaboration, knowledge sharing and administrative work. By following the recommendations, the company should be able to mitigate these challenges and improve the overall performance of the process. One conclusion that can be

drawn from the recommendations is the importance of creating a holistic view of the process before moving forward with radical changes in processes. This is supported by previous findings in the company which point previous mistakes where IT systems have been implemented with a narrow focus and in the end becoming obsolete.

The finding of this study clearly shows how complex and difficult it is to manage and further improve a process with many stakeholders. The study contributes to organisational research by highlighting challenges within a highly recognised international standard, namely PPAP. The standard is implemented globally and is therefore highly relevant for improvement projects in other organisations. The identified challenges and recommendations can be used as a template for other research and for organisations looking to improve their work with PPAP.

6.2 Discussion of Methodology

This research study was conducted a case study focusing on a specific department at a large OEM. The study focused on the perspective of a function within the department to gain an understanding of the challenges the function phased. To broaden the view, more departments could have been involved in the study to see all sides of the issues mentioned and get a better holistic perspective. The authors chose this scope to achieve a deep grasp of the role and the existing challenges. Furthermore, the time needed to understand the process and conduct the interviews created a need to have a narrow focus.

Interviews and observations were chosen as methods to gather empirical data due to the complexity of the process and its highly variable nature. The interviews were semi-structured which enabled the interviewees to elaborate on areas which were of interest. To capture a more structured data set, more structured interviews could have been used. This would have made it easier to codify and analyse the data (Bryman & Bell, 2011). However, the need for flexibility was deemed too high and therefore semi-structured interviews was seen as the best choice. Another method that could have added value to the study, is focus groups. Using focus groups could have increased the amount of qualitative data and added to the involvement of the OEM. The authors deemed that focus groups would not result in enough focus on the individual employee and that not all employees would be heard which is supported by Bryman & Bell (2011). The observations used in the study was mainly used as a complement to the interviews. The reason behind this was due to the process being hard to observe and many of the actions taken are invisible. To capture a more precise view of exactly what the employees do in the process, shadowing could have been an interesting method to use. This would have required selecting a few individuals to follow around during an extended period of time and codifying their actions. The authors did not pursue this method since the work of an SQE consists of more that the PPAP and that was the focus of the thesis.

As mentioned in chapter 3.5 Research Quality Criteria an important aspect to ensure is credibility. Firstly, to ensure that the credibility of the conclusions was high, the authors continuously checked with the interviewees and stakeholders if they found that the descriptions were consistent with their view of the world. When discrepancies were found, they were discussed and corrected to adequately and fairly depict the situation at the OEM. Furthermore, the recommendations were discussed with several stakeholders to ensure that they were feasible and fit with the strategy moving forward. Secondly, as mentioned earlier, the use of interviews and observations in conjunction created a basis for triangulation (Bryman & Bell, 2011). The authors also used several sources to corroborate statements to further triangulate the findings. This resulted in conclusions that are credible. ‘

The social validity of the study also be deemed high since the all the empirical data came from interviewees participating in the social context that was studied. This means that, according to the authors, that the results accurately depict the real-world situation. This is especially true for the ecological context of validity which is further explained in chapter 3.5 Research Quality Criteria. Since the results are qualitative in nature, the measurements of its validity will be difficult as stated earlier. In order to add weight to the findings, the mentioned challenges were quantified in chapter 5.2 Cause and Effect Analysis & Focus Areas. This increases the possibility to measure the results and see that the focus areas were selected to both causality and volume.

To ensure that the study has high reliability the authors conducted 35 interviews with 29 unique employees from different departments at the OEM. This was done to ensure that subjectivity and bias was eliminated from the conclusions. The large data set created a holistic view of the challenges and the authors made sure to corroborate statements, as mention previously, to mitigate one interviewee influencing the results too much. Also, by having a clear and descriptive methodology it increases the replicability of the study. However, since the study is qualitative in nature and the interviews anonymised to protect the interviews, the exact same data set will be hard to recreate.

Overall, the methods selected to fulfil the purpose of the study was deemed satisfactory by the authors. Furthermore, by focusing on the quality criteria discussed above, the results are considered to hold high standards.

6.3 Discussion of Further Studies

This study was focused a specific step in the process of bringing a new product to market in collaboration with suppliers. To further gain more knowledge about this process, four areas of further studies were identified. Firstly, chapter 5.3 Recommendations outlines a study focusing on PPAP from the supplier perspective. In the chapter, the suggestion is outlined thoroughly. Secondly, a deeper investigation into supplier cooperation and collaboration in other industrial verticals. Thirdly, a further study into supplier selection and lastly, a future study regarding how to measure the effects of proactive quality.

The findings of the study show how important collaboration and cooperation with suppliers is for the success of the end product. It would therefore be interesting to further investigate other industrial verticals to see if these challenges persist or if it is something that can be isolated to the automotive industry. This would increase the generalisability of these factors and further increase the knowledge base regarding buyer and supplier relationships.

Another finding of the study was that the supplier selection process has a significant impact on the outcome of the quality of the PPAP. It would therefore be interesting to further study how large OEMs select their suppliers and what characteristics are actually used to make the selection. Studying exactly how metrics are used to evaluate suppliers and to investigate what is most important for the OEM. By studying this and comparing multiple historical cases the OEM could see what the main driver for supplier selection actually is and if there are discrepancies with what is communicated internally.

The PPAP is done to secure the quality of the part in the long term and it would therefore be interesting to study the effects of the proactive quality work at the OEM. This was identified as a challenge during initial talks with the OEM since it is hard to derive the actual value of working with proactive quality. By studying the work that is conducted in the initial stages of a products life and comparing it to issues met after product launch, it could be possible to derive

measurements for proactive quality. This would be of immense value for large production companies to highlight and put a number on the importance of proactive quality.

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Appendix

Appendix A – PPAP Description of Elements (AIAG)

PPAP elements		Description of element
1.	**Design Records**	Documentation that shall include a copy of the customer and supplier's drawing, a copy of the purchase order, material specifications and such
2.	**Authorized Engineering Change Documents** **Customer Engineering approval**	Documentation if any changes to the part have been made, typically an Engineering Change Notice.
3.	**Customer Engineering Approval**	Evidence of approval by the customer engineering departments that the supplier must provide
4.	**Design FMEA (if supplier is design responsible)**	Design Failure Mode and Effects Analysis (DFMEA), a cross-functional activity that examines design risk by exploring the possible failure modes and their effects on the product or customer and their probability to occur.
5.	**Process Flow Diagrams**	The Process Flow Diagram outlines the entire process for assembling the component or final assembly in a graphical manner. The process flow includes incoming material, assembly, test, rework and shipping.
6.	**Process FMEA**	Process Failure Mode and Effects Analysis reviews all of the steps in the production process to identify any potential process quality risk and then document the applied controls for mitigation. The PFMEA is also a living document and should be updated even after the product is in normal production. The PFMEA also handles risks that cannot be designed away (from DFMEA)
7.	**Control Plan**	The Control Plan is an output from the PFMEA. The Control Plan lists all product Special Characteristics and inspection methods required to deliver products that continually meet the customer quality requirements.
8.	**Measurement System Analysis Studies**	Measurement System Analysis (MSA) studies will include Gage Repeatability & Reproducibility (GR&R) studies on measurement equipment used during assembly or quality control checks. Calibration records for all gages and measurement equipment must be included.
9.	**Dimensional Results**	Dimensional layout of sample parts is required to validate the product meets the print specifications. The samples should be randomly selected from a significant production run usually at least 30 pieces. Each dimension on the drawing is measured on the final assembly to make sure that it falls within specification. The results are

		recorded in a spreadsheet and included within the PPAP submission
10.	**Material, Performance Test Results**	This element should contain a copy of the Design Verification Plan and Report (DVP&R). The DVP&R is a summary of every validation test performed on the part. It should list each and every test performed, a description of how the test was performed, and the results of each test. This section may also include copies of all the certification documents for all materials (steel, plastics, etc.) listed on the prints. The material certification shall show compliance to the specific call on the print.
11.	**Initial Process Studies/ Capability Study**	Initial process studies will be done on all the production processes and will include Statistical Process Control (SPC) charts on the critical characteristics of the product. These studies demonstrate that the critical processes are stable, demonstrate normal variation and are running near the intended nominal value.
12.	**Quality Laboratory Documentation**	Qualified laboratory documentation consists of the industry certifications for any lab that was involved in completing validation testing. This could be for an in-house test lab or any offsite contracted test facilities that were used for validation or material certification testing.
13.	**Appearance Approval Report (AAR)**	The Appearance Approval Report (AAR) is applicable for components affecting appearance only. This report verifies that the customer has inspected the final product and it meets all the required appearance specifications for the design. The appearance requirements could include information regarding the colour, textures, etc.
14.	**Sample Product**	Sample production parts are sent to the customer for approval and are typically stored at either the customer or supplier's site after the product development is complete. A picture of the production parts is usually included in the PPAP documentation along with documentation regarding the location that the parts are being stored
15.	**Master Sample**	A master sample is a final sample of the product that is inspected and signed off by the customer. The master sample part is used to train operators and serves as a benchmark for comparison to standard production parts if any part quality questions arise.
16.	**Checking Aids**	This is a detailed list of checking aids used by production. It should include all tools used to inspect, test or measure parts during the assembly process. The list should describe the tool and have the calibration schedule for the

		tool. Checking aids may include check fixtures, contour, variable and attribute gages, models or templates. MSA may be required for all checking aids based on customer requirements.
17.	**Customer Specific Requirements**	This element of the submission package is where any special customer requirements are contained. For bulk materials, the customer specific requirements shall be recorded on the "Bulk Material Requirements Checklist".
18.	**Part Submission Warrant (PSW)**	The Part Submission Warrant (PSW) form is a summary of the entire PPAP submission. A PSW is required for each of part number unless otherwise stated by the customer. The PSW includes: The reason for submission (design change, annual re-validation, etc.) The level of documents submitted to the customer Declaration of part conformity to customer requirements A section provided for any required explanation or comments Supplier authorized person signature along with contact information An area for the customer to indicate disposition of the PPAP

Appendix B – Documentation Requirements Depending on Submission Level (AIAG)

DOCUMENTATION REQUIREMENTS

Requirement		Submission Level				
		level 1	level 2	level 3	level 4	level 5
1.	Design Record	R	S	S	*	R
	- for proprietary components/ details	R	R	R	*	R
	- for all other components/details	R	S	S	*	R
2.	Engineering Change Documents, if any	R	S	S	*	R
3.	Customer Engineering approval, if required	R	R	S	*	R
4.	Design FMEA	R	R	S	*	R
5.	Process Flow Diagrams	R	R	S	*	R
6.	Process FMEA	R	R	S	*	R
7.	Control Plan	R	R	S	*	R
8.	Measurement System Analysis Studies	R	R	S	*	R
9.	Dimensionnal Results	R	S	S	*	R
10.	Material, Performance Test Results	R	S	S	*	R
11.	Initial Process Studies	R	R	S	*	R
12.	Qualified Laboratory Documentation	R	S	S	*	R
13.	Appearance Approval Report (AAR), if applicable	S	S	S	*	R
14.	Sample Product	R	S	S	*	R
15.	Master Sample	R	R	R	*	R
16.	Checking Aids	R	R	R	*	R
17.	Records of Compliance	R	R	S	*	R
	With Customer Specific Requirements	R	R	S	*	R
18.	Part Submission Warrant (PSW)	S	S	S	S	R
	Bulk Material Checklist	S	S	S	S	R

S = The organization shall submit to the customer and retain copy of records or documentation items at appropriate locations .

R = The organization shall retain at appropriate locations and make available to the customer upon request .

* = The organization shall retain at appropriate locations and submit to the customer upon request.

Appendix C – Interview Template

Questions

1. What is you background & current role?
2. How is your current role connected to PPAP?
3. Please explain how you work with PPAP in relation to stage 1, 2, 3 & 4?
    a. *How does your work with PPAP start?*
    b. *How is the workload distributed in the different stages?*
    c. *What are the main challenges you face in the different stages/gates? (1-4)*
    d. *What preparation/work is most important to succeed with a PPAP approval?*
4. How does communication work internally and externally within a project?
5. Is there a difference between small or large projects in terms of outcomes?
6. What are the main challenges that exist with PPAP in your daily work?
7. What are your key success factors in your work, that you do, that leads to a stable product launch and PPAP?
8. Do you have any other recommendations what we should look into and who we should talk to further investigate PPAP?

Appendix D – Quantification of Challenges

Challenge	Grouping	Count
Chase after documents	Chasing after documentation	3
PPAP Documentation from previous parts not available	Chasing after documentation	3
Collaboration between functions is challenging	Collaboration affected by location and individual performance	10
Changes after stage 3 make PPAP approval planning hard	Collaboration affected by location and individual performance	1
Distance between functions affects collaboration	Collaboration affected by location and individual performance	3
Unclear decision taking in the projects (Goes through gate even though not finished)	External & Internal communication challenges	2
Internal Communication	External & Internal communication challenges	8
External communication with supplier	External & Internal communication challenges	5
Changes regarding design not communicated	External & Internal communication challenges	1
Infrequent communication in small projects	External & Internal communication challenges	1
Hard to put demands internally	Hard to give feedback internally	5
Harder to work with producing suppliers compared to developing suppliers: Design & planning issues	Hard to give feedback internally	1
Lack of knowledge in FMEA from PD	Hard to give feedback internally	3
Hard to understand the process for new SQES/Buyers	Lack of lessons learned and knowledge transfer	3
Tacit knowledge from experienced SQEs not available for the organisation	Lack of lessons learned and knowledge transfer	3
Lack of project learning, lessons learned	Lack of lessons learned and knowledge transfer	1
Lack of involvement for SQE in project	Lack of SQE involvement in projects	1
Hard to keep updated with the project, due to travelling:	Lack of SQE involvement in projects	2
Late involvement for SQEs in projects	Lack of SQE involvement in projects	4
No time for SQEs to be involved fully in projects and in the field at the same time	Lack of SQE involvement in projects	2
Lack of system support for documentation and communication	Lack of system support for documentation handling	4
Hard to keeping track of activities in PPAP	Lack of system support for documentation handling	4
Lacking knowledge regarding PPAP from other stakeholders	Low knowledge about PPAP and what it entails	10
SQE blamed for project/component delays	Low knowledge about PPAP and what it entails	7
Lack of transparency in terms of status and reporting	Low knowledge about PPAP and what it entails	1

Fragmented PPAP element submission with no standard	No standardised way of receiving documentation	4
Departments are working in Silos	Poor understanding of other's role in the PPAP	8
Understanding the work of other functions and colleagues	Poor understanding of other's role in the PPAP	6
Project collaboration issues	Unclear roles and responsibilities in project teams	6
Unclear responsibilities	Unclear roles and responsibilities in project teams	4
Total		**116**

Grouping	**2nd level grouping**	**Count**
Low knowledge about PPAP and what it entails	Knowledge sharing	18
External & Internal communication challenges	External & Internal Communication	17
Poor understanding of other's role in the PPAP	Knowledge sharing	14
Collaboration affected by location and individual performance	Collaboration between stakeholders	14
Unclear roles and responsibilities in project teams	Collaboration between stakeholders	10
Chasing after documentation	High administrative workload	6
Hard to give feedback internally	External & Internal Communication	9
Lack of lessons learned and knowledge transfer	Knowledge sharing	7
Lack of SQE involvement in projects	Collaboration between stakeholders	9
No standardised way of receiving documentation	High administrative workload	4
Lack of system support for documentation handling	High administrative workload	8
Total		**116**

2nd level grouping	**Count**
Knowledge Sharing	39
External & Internal Communication	26
Collaboration between stakeholders	33
High administrative workload	18
Total	**116**

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