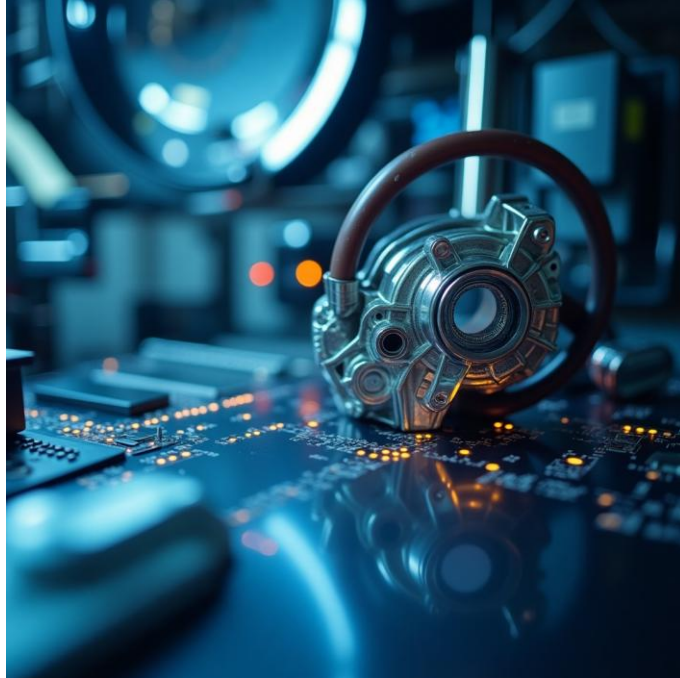




CHALMERS
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Streamlining APQP and PPAP for Enhanced Supplier Quality

A Capability-Based Case Study at a Global OEM

Master's thesis in Quality and Operations Management

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Cover:

The illustration shows an abstract component in a technological setting, highlighting the topic of developing complex components. It was created by Generative AI using the thesis title as prompt.

Gothenburg, Sweden 2025

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SUMMARY

In the dynamic market of Original Equipment Manufacturers (OEMs), maintaining customer satisfaction while attracting new business depends on the consistent delivery of high-quality products. As OEMs rely on suppliers for critical components, ensuring supplier compliance with specifications and performance expectations is essential. To support this, industry-standard frameworks such as Advanced Product Quality Planning (APQP) and the Production Part Approval Process (PPAP) developed by Automotive Industry Action Group (AIAG), are used to guide collaboration, reduce risk, and validate quality throughout the product development lifecycle.

This thesis investigates how APQP and PPAP are applied at a global OEM and identifies organizational and procedural challenges affecting their use. Using the Capability Maturity Model Integration (CMMI) framework, the study assesses current practices, identifies key gaps, and proposes targeted actions to improve process maturity. The research is based on interviews with internal stakeholders across SQM, R&D, procurement, logistics, and digital, supported by internal documentation and key informants.

The findings highlight challenges such as fragmented task ownership, inconsistent system usage, limited cross-functional involvement, and gaps in training and supplier integration. To address these, the study outlines short- and long-term actions including clearer role definitions, improved digital alignment, and formalized training routines.

The thesis contributes to quality and operations management by demonstrating how maturity models like CMMI can support structured improvement of APQP and PPAP in complex, cross-functional environments.

Keywords: APQP, PPAP, CMMI, Organizational standardization, Quality planning, OEM case study

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Nomenclature

AAR – Appearance Approval Report
AIAG – Automotive Industry Action Group
APQP – Advanced Product Quality Planning
CMMI – Capability Maturity Model Integration
DFMEA – Design Failure Mode and Effects Analysis
FTR – First Time Right
IATF – International Automotive Task Force
IPM – Integrated Project Management
MSA – Measurement System Analysis
OEM – Original Equipment Manufacturer
OPD – Organizational Process Definition
OT – Organizational Training
PDCA – Plan-Do-Check-Act
PFD – Process Flow Diagram
PFMEA – Process Failure Mode and Effects Analysis
PO – Purchase Order
PP – Project Planning
PPAP – Production Part Approval Process
PSW – Part Submission Warrant
QM – Quality Management
R&D – Research & Development
R@R – Run at Rate
SLA – Supplier Logistics Assurance
SQM – Supplier Quality Management

1. Introduction

This chapter serves as the introduction to this paper, giving a background for the topic of analysis while presenting the purpose and research questions of the study. Furthermore, the delimitations are defined.

1.1 Background

With worldwide competition and volatile customer demands, the survival of companies depend on their ability to attract and satisfy customers (Ebrahimi & Sadeghi, 2013; Weckenmann et al., 2015). Customer satisfaction is closely tied to their perceived quality of a product or service, making a comprehensive quality management system essential (Adam et al., 1997). However, quality is a multidimensional concept, varying by context (Ebrahimi & Sadeghi, 2013; Hoyle, 2011). As stated by Ebrahimi & Sadeghi (2013), quality can be defined in terms such as 'conformance to requirements' or 'fitness to use'. According to Hoyle (2011, p.10), a generally accepted definition per the Oxford English dictionary is that quality is "*The degree to which a set of inherent characteristics fulfil a need or expectation that is stated, generally implied or obligatory.*"

Hoyle (2011) further discusses the relation between supply chain management and quality management (QM), stating that for each transaction within a supply chain, the buyer needs to be satisfied. The interplay between supplier and buyer is related to supplier quality management (SQM), which regards the quality-oriented collaboration between the two actors (Salimian et al., 2020). Through a proactive approach, SQM strives to ensure that suppliers can consistently deliver goods that are compliant with the buyers' requirements.

To collaboratively drive down cost and complexity in the supply chain, the Automotive Industry Action Group (AIAG) was created in 1982 by the Big Three of the automotive industry (General Motors, Stellantis/Chrysler and Ford Motor Company) (AIAG, n.d.). The 'Quality Core Tools' are some of the key developments of the group, and they include Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP). APQP and PPAP are two widely used SQM processes in the automotive industry, which in combination guide the collaboration between buyers and suppliers in component industrialization (Rocha & Salerno, 2014). APQP is a phase-driven, cross-functional approach for ensuring that new products and components satisfy customer needs. From planning to production and feedback, APQP strives to validate all products and components to prevent defects and rework (AIAG, 2008; Rocha & Salerno, 2014). On the other hand, PPAP is a process for validating the capability of suppliers to deliver on specification, serving as a formal series-production sign off. Through PPAP, buyers can incentivize suppliers to prove that their processes and products can perform as intended (AIAG, 2006; Doshi & Desai, 2016; Gawlik et al., 2012).

Research conducted on the topics of APQP and PPAP have primarily been conducted in isolation. Li et al. (2011) outlined that APQP is a generally applicable programme that can improve production quality and decrease costs. However, while Li et al. (2011) declare that APQP can be used to standardize manufacturing, Rocha & Salerno (2014) declare that APQP needs to be consistently well monitored to not jeopardize the success of new products. Just as APQP, PPAP is described as a procedure utilized to decrease production costs and ensure quality compliance between supplier and buyer (Doshi & Desai, 2016; Gawlik et al., 2012). While Doshi & Desai (2016) underline how PPAP improves buyer-supplier relations and helps the

continuous improvement of product quality, Gawlik et al. (2012) highlight that reaching PPAP with a resulting failure rate of 0 ppm requires further research.

As globalization, customer expectations, and digital complexity increase, organizations must continuously refine their QM practices to remain competitive (Weckenmann et al., 2015). In this context, streamlining APQP and PPAP may represent a practical pathway for OEMs to strengthen their quality assurance and adaptability in a dynamic market. To support this study, the Capability Maturity Model Integration (CMMI) framework is introduced to assess and improve the maturity of quality-related processes. CMMI, originally created for improving IT processes, has developed to become a framework in guiding additional areas of business, such as SQM (Ho et al., 2016).

1.2 Purpose

In response to the interest in streamlining APQP and PPAP, this research aimed to examine how a global OEM utilizes these processes and derive opportunities for streamlining component industrialization. By identifying key challenges and gaps in the OEM's current practices through the usage of CMMI, this study sought to develop a set of actions for further improving supplier quality management.

1.2.1 Research Questions

To evaluate the OEM's current capabilities in APQP and PPAP, it is essential to apply a structured framework for assessing process maturity. CMMI provides such a framework, enabling systematic analysis of organizational practices (Chrissis et al., 2011). This leads to the first research question:

- How can the maturity of APQP and PPAP processes at an OEM be evaluated using the Capability Maturity Model Integration (CMMI) framework?

Prior research emphasizes that successful implementation of APQP and PPAP is often hindered by organizational and procedural shortcomings (Rocha & Salerno, 2014; Gawlik et al., 2012). To explore these challenges, the second research question is formulated:

- What organizational and procedural gaps influence the application of APQP and PPAP?

Addressing these gaps is crucial for enhancing process maturity. Accordingly, the third research question aims to identify actions that can support the improvement of APQP and PPAP processes:

- What actions can support the advancement of APQP and PPAP process maturity?

1.3 Delimitations

The focus of the study was on the SQM organization of a global OEM. Due to the geographical context, the analysis primarily reflects a European perspective, however it also incorporates insights from other regions, such as Asia-Pacific (APAC).

As APQP and PPAP are complex processes with multiple layers of detail, the study does not cover low-level processes associated with either. Examples of these include Process Failure Mode and Effects Analysis (PFMEA), used to identify potential operational failures, and Measurement System Analysis (MSA), used to evaluate and quantify measurement variability. Furthermore, although APQP includes several

steps prior to component industrialization, such as supplier sourcing and the formation of cross-functional teams, these are excluded from the scope as they encompass several additional factors that needs consideration.

While APQP and PPAP is applied in both vehicle and component development, this study focuses specifically on their application in component industrialization and does not fully consider the broader context of vehicle development.

To maintain general applicability, the study does not present an implementation plan tailored to the case company but instead general actions that can be interpreted and applied by other OEMs.

Lastly, as the purpose of this study was to explore internal organizational actions that may enhance supplier quality, the direct perspective of suppliers has not been explicitly included.

2. Theoretical Framework

This chapter presents the theoretical foundation used to analyze APQP and PPAP practices at the OEM. It begins with key principles in QM, including the Triple Constraint, First Time Right, and PDCA, to frame how organizations balance quality, time, and cost. The section then introduces APQP and PPAP as core tools in automotive SQM, supported by standards such as IATF 16949. To evaluate process maturity and guide improvement efforts, the CMMI framework is used. Together, these theories, models and standards provide the basis for assessing gaps and potential improvement.

2.1 Quality Management

Quality management (QM) in its early days, as described by Ingason (2020), adopted a quality view primarily through the lens of quality control, focusing on identifying defects and ensuring that the product met specifications. However, throughout the last century, various iterations have suggested different approaches to quality. Taylor (1911) was among the first to propose a perspective emphasizing standardization and process efficiency, with quality control as a key tool for ensuring conformance. Later, Juran introduced his framework, the Juran Trilogy, which advocated for managing quality through planning, control, and continuous improvement (Juran, 1986). Deming also put forward a philosophy that emphasized the importance of systems thinking and called for a need for continuous quality improvement (Petersen, 1999).

From a focus on inspection of products, QM has evolved into a holistic view to become a critical management tool and philosophy for modern business. With widespread usage, ISO 9001 represents the most recognized QM framework, supporting long-term performance and stakeholder satisfaction (Fonseca, 2015). The refined ISO 9001:2015 standard incorporates seven core principles which are as follows: 1) Customer Focus, 2) Leadership 3) engagement of People 4) Process Approach 5) Improvement 6) Evidence-based Decision Making 7) Relationship Management. These principles guide organizations in navigating complex environments and fostering continuous improvement (Fonseca, 2015).

When considering quality, it should not be regarded as a fixed state of a product or service, but the degree to which its inherent characteristics are able to satisfy the need or expectation of the user (Hoyle, 2011). By treating quality as an overall business strategy (the big Q) instead of focusing on the entity of a product (the small q), Hoyle (2011) suggests a better alignment of business. According to Fonseca (2015), effective QM necessitates an organizational effort beyond quality compliance, to ensure quality becomes a shared value across all levels of the organization. Effective use of QM can further be seen closely linked to organizational performance in leveraging competitiveness, customer satisfaction and financial outcomes (Ebrahimi & Sadeghi, 2013). However, the practical results of a QM initiative often vary. Several studies emphasize that when QM initiatives fail, it is often not due to flaws in the concept itself but rather flaws with how it is implemented (Seetharaman et al., 2006). Common challenges include a lack of top management commitment, vague implementation plans, or overlooking the cultural changes required to support quality initiatives throughout the organization. Seetharaman et al. (2006) points out that for QM to be effective, it must be supported by long-term planning, appropriate training, and clear, measurable objectives that are embedded at all levels of the organization. In addition, Linderman et al. (2004) argue that effective quality management is fundamentally tied to an organization's ability to create and manage knowledge. Linderman et al. (2004) apply Nonaka's knowledge creation theory to

show how QM practices contribute to organizational learning through the processes of the SECI model: socialization, externalization, combination, and internalization. These processes enable the transformation of individual experience into shared organizational knowledge, which supports continuous improvement and enhances long-term performance. Thus, successful implementation of QM depends not only on the application of tools and standards but also on fostering a knowledge-creating environment within the organization (Linderman et al., 2004). Further analysis of QM can be done through the Triple Constraint Framework, which is further explored in the following.

2.1.1 Triple Constraint

Interpreting quality can be done through the framework known as the Triple Constraint which consists of the three criteria quality, cost and time (Adler, 2018). The illustration as seen in *Figure 1*, is commonly used to understand the correlation between time and cost in relation to quality outcome, suggests that changes of one criterion will inevitably affect the others (Pollack et al., 2018). From an organizational perspective it is not uncommon to encounter challenges within the Triple Constraint inside projects. Van Wyngaard et al. (2012) highlights the expression “*Good, fast or cheap? Pick two*”, emphasizing that trade-off decisions are a necessity to maintain quality as an attempt to push for all elements will result in the failure of one of them. They further add that constraints often follow an asymmetric and nonlinear relationship, suggesting a need to continuously iterate trade-off decisions.

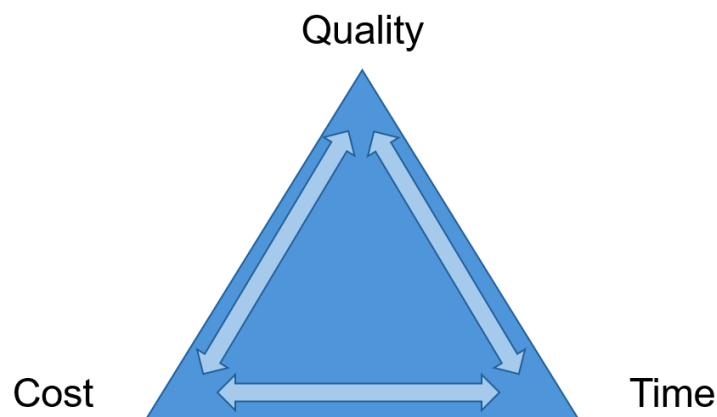


Figure 1 – Illustration of the Triple Constraint

Addressing the trade-off between time and cost is further pinpointed in production time crashing, a method of deliberately shortening project activities by allocating more resources (Liao et al., 2020). The product time crashing curve argues that while time crashing can to some extent prove cost beneficial, it rapidly escalates after a certain optimum point due to the nonlinear relationship where costs increase exponentially as time reduces. Orm & Jeunet (2018) further expand on the implications of time reduction by examining the practice of overlapping project activities. This approach, often used to accelerate delivery, involves initiating downstream tasks based on incomplete or evolving inputs from upstream stages. While effective in reducing timelines, it introduces a significant risk of rework, thereby increasing costs and potentially reducing quality. Their analysis underscores the core message of the Triple Constraint that attempting to improve one dimension such as time risks impacting the others. Moreover, the need for rework reflects the non-linear and asymmetric nature of these trade-offs, where accelerating activities do not only linearly increase cost, but can amplify risk in unpredictable ways.

In addition to balancing cost, time, and quality for project success, recent studies highlight that organizational support—such as management commitment, resource availability, and supportive culture—can significantly moderate these relationships. High organizational support can mitigate the negative impacts of constraint overruns, leading to improved project outcomes even when challenges arise (Watanabe et al., 2024). But while the Triple Constraint illustrates the inevitable trade-offs between time, cost, and quality, organizations may also approach these tensions in ways that mitigate their appearance. One such approach is to prevent quality degradation by building quality into the process from the start using the First Time Right – Principle (FTR).

2.1.2 First Time Right

FTR can be understood as a principle in manufacturing to prevent quality defects by promoting employees to take immediate accountability of quality before progression downstream (Poppendieck, 2002). Kumar et al. (2023) tells that quality issues should be addressed in the design stage, highlighting the integration of FTR upstream. By emphasizing predictive quality thinking over reactive, FTR enables better integration of quality assurance throughout the entire product design and manufacturing process (Kumar et al., 2023). Moreover, Ford & Gosling (2024), although pinpointing an ongoing struggle in the construction industry, underscore the broader organizational barriers of FTR implementation. Their findings suggest that cost and schedule often dominate decision-making at the expense of quality, which increases the likelihood of rework and delays - risks that could be significantly mitigated through an FTR approach.

The necessity for upfront perfection may however become misinterpreted. Poppendieck (2002) notices that while FTR aims to empower ownership of quality it can be mistaken to become an exhaustive approach for upfront perfection, leaving the organization with counterproductive processes. If such misinterpretation occurs, consequences may follow in loss of responsibility, excessive documentation, and inflexibility. In response, they argue that FTR must emphasise rapid feedback loops and allow for continuous improvement to avoid an approach that ends up hindering the organisations processes. This notion of continuous improvement is seen as the core message of Plan-Do-Check-Act (PDCA).

2.1.3 Plan-Do-Check-Act

PDCA is an organizational model for continuous improvement that follows a four-step iterative cycle. According to ISO 9001:2015, the elements of PDCA are defined as follows in *Figure 2* (SIS, 2015).

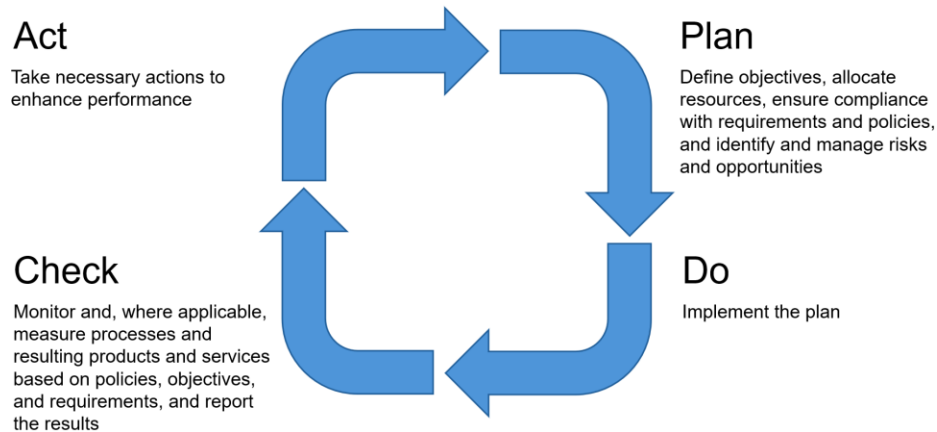


Figure 2 – The Four Steps of PDCA

PDCA places a strong emphasis on risk-based thinking by encouraging organizations to proactively identify and address potential deviations before they occur. As Ezrahevich et al. (2017) points out, ISO 9001:2015 emphasize this mindset at the core of its quality management system, particularly during the “Plan” phase. This includes defining risk assessment criteria, evaluating potential hazards, and establishing mitigation strategies to encourage preventive actions and continuous improvement mechanisms before problems arise.

In practice, PDCA fosters a structured approach to problem-solving and organizational learning, both of which are essential for operational excellence and long-term strategic growth (Jagusiak-Kocik, 2017). Managerial engagement, particularly during the “Plan” and “Do” phases, reinforces a culture of collective responsibility and commitment to continuous improvement. Realyvásquez-Vargas et al. (2018) argue that once an organization standardizes the PDCA cycle as a routine learning process, it enhances operational consistency and contributes to a sustainable competitive advantage. Taufik (2020) supports this by emphasizing that standardization ensures consistent quality and reliability in operations. Further he pinpoints the importance of the “Act” phase in closing the feedback loop and enabling the cycle to repeat and evolve. From a continuous learning perspective, this stage validates the outcomes from the “Check” phase and informs appropriate next steps (Pietrzak & Paliszkievicz, 2015). If only minor deviations are observed, corrective actions can be taken within the existing framework, reflecting single-loop learning, where strategies remain unchanged. However, when more fundamental issues are identified, the “Act” stage can lead to double-loop learning, prompting the organization to reassess and potentially alter its goals, assumptions, or strategies (Pietrzak & Paliszkievicz, 2015). As the double-loop learning not only corrects errors but challenges their underlying assumptions on a deeper level, it emphasizes a proactive approach to address issues.

The principles of PDCA and continuous learning are not only theoretical constructs but are also embedded in established industry standards. In the automotive sector, IATF 16949 is considered a recognized quality management standard that formalizes many of these continuous improvement principles into operational practice.

2.1.4 IATF 16949

IATF 16949 is a recognized quality standard in the automotive industry developed by the International Automotive Task Force (IATF), which consists of major automotive manufacturers and associations including AIAG (IATF, n.d). The IATF standard is related and compatible with the international ISO: 9001:2015 standard, however IATF's coverage is specifically aimed at requirements for the automotive industry (Yılmaz & Acaroğlu, 2024). Yılmaz & Acaroğlu (2024) highlight that IATF complements the generic ISO:9001 standard by adding value to the automotive sector in different areas including supply chain, operational performance, people and technology. Ultimately it helps automotive companies gain higher control of their quality management system which ensures continuous improvement of quality while staying competitive (IATF, n.d). Building on the requirements set by IATF 16949, Advanced Product Quality Planning (APQP) serves as a structured methodology for planning and managing quality throughout component industrialization.

2.1.5 Advanced Product Quality Planning

APQP is a systematic methodology for developing new products. Through the inherent use of statistical tools and QM techniques, the methodology aims to reduce costs, enhance production capabilities, and ultimately ensure higher product quality and customer satisfaction (Li et al., 2011). APQP is in line with the IATF 16949 standard – in fact, the methodology is expected to be used in ensuring compliance with the standard. The general guidelines of AIAG define five sequential phases of APQP as seen in *Figure 3: Plan and Define (1), Product Design and Development (2), Process Design and Development (3), Product and Process Validation (4), Feedback, Assessment and Corrective Action (5)*. For a further definition of the inherent phases, see *Appendix A*.

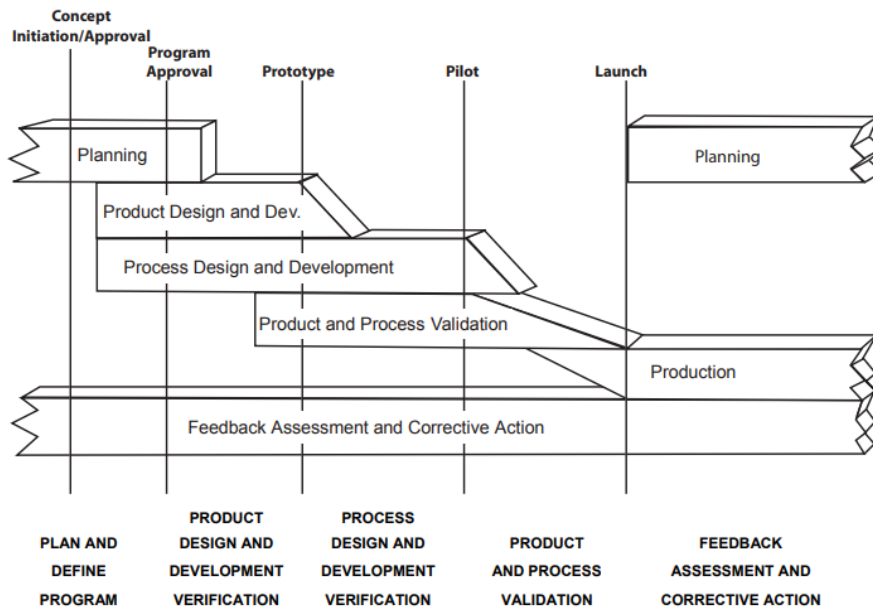


Figure 3 – APQP Phases and Timing¹

¹ Reprinted from APQP and Control Plan Second Edition with permission from AIAG (Automotive Industry Action Group).

According to Stamatis (2018), effective execution of APQP requires strong cross-functional collaboration. Stamatis (2018) emphasizes that success relies on the involvement of teams with broad experience and knowledge, and further identifies clear role definitions, proactive feedback, consistent communication, and mutual acknowledgement as key enablers of high-performing APQP teams. Although not formally a study on APQP, Oliva & Watson (2011) describe how the absence of structured cross-functional processes in supply chain planning led to persistent misalignment and duplicated efforts. Their findings underscore the importance of explicit validation steps, shared decision-making procedures, and clear ownership in overcoming functional silos and achieving coordinated planning outcomes.

2.2 Supplier Quality Management

SQM, serving as a bridge between supply chain management and quality management, involves systematic monitoring and assessment of suppliers to ensure that products meet customer requirements (Burgess et al., 2023). While earlier studies show that buyers historically relied solely on the inspection of incoming goods (Forker, 1997), Flynn & Flynn (2005) adds that buyer-supplier collaboration has additional benefits on supply chain performance. Furthermore, Flynn & Flynn (2005) defines how a higher degree of formalization and collaboration proves increasingly beneficial for performance. The notion of collaborating with suppliers is also investigated by Noshad & Awasthi (2015). Noshad & Awasthi (2015) deduce how collaboration with suppliers proves essential for quality development and continuous improvement, and how key practices include sharing long-term goals, intensive communication and engaging suppliers early in product and process development.

In addition to collaborative efforts, Lee & Li (2018) describe how investing in supplier development is an additional strategy for managing product quality. Through investments in improving the quality of supplier operations, benefits are gained for both parties in terms of reduced costs and increased quality (Lee & Li, 2018). Supplier investments may also include support and education in best practices and know-how, which are applicable for suppliers who have a lower degree of experience (Bai & Sarkis, 2016; Lee & Li, 2018). Thus, three areas for improving SQM are inspection, investment and collaboration, as further discussed below.

2.2.1 Inspection of incoming goods

In the context of SQM, buyers should inspect the conformance of requirements upon receiving goods from a supplier. Through verifying the geometry, appearance and performance of items, buyers may identify defects early in the development process, not to have a compound effect on the subsequent development. Lee & Li (2018) outline that the ability of buyers to accurately identify bad-quality products depends on the resources invested in inspection efforts. Furthermore, Lee & Li (2018) highlight that defects identified upon initial inspection are rejectable due to contractual obligations, while defects that fail at a later stage can fall under the responsibility of the buyer due to difficulties in deciding who is accountable. As a remedy, Lee & Li (2018) suggest that buyers should ensure visibility of material flows to enable the tracking of root causes. In a study on vendor-managed inventories and quality inspection on the buyer side, it was concluded that companies do not only need rigid inspection processes, but also strategies on how to manage defective items and inspection errors (Attila, 2024). Furthermore, Attila (2024) highlighted the importance of incorporating risk management to account for potential inspection errors.

2.2.2 Investment in supplier development

To improve the quality of incoming goods prior to inspection, buyers may invest resources in the development of suppliers. In the quest of improving supplier development to gain competitive advantage, buyers have a variety of investments to choose from (Bai & Sarkis, 2014). These investments can be classified as either tangible or intangible (Bai & Sarkis, 2014; Lee & Li, 2018). Examples of tangible investments include aid in financing factory expansion or financing of high-quality materials and tooling (Bai & Sarkis, 2014; Lee & Li, 2018). Intangible investments include knowledge sharing and supplier assistance programs (Bai & Sarkis, 2014; Lee & Li, 2018). Through these investments, complementary gains can be acquired as suppliers become more resource efficient, leading to lower operational costs (Lee & Li, 2018). While Lee & Li (2018) suggest investment in quality management systems, improvement to production processes and use of high-quality material and tooling, Bai & Sarkis (2014) also suggest collaborative efforts as a compliment to investment and strategies for shared savings.

2.2.3 Collaboration with suppliers

In a study conducted by Salimian et al. (2020), it was concluded that manufacturing is no longer just about production. Instead, organizations should strive for higher levels of trust and commitment among all organizations within the supply chain, to ensure that value is created for the end customer. Through not only investing in supplier development, but also fostering a collaborative approach, a higher level of quality performance can be achieved (Salimian et al., 2020; Bai & Sarkis, 2014). In an earlier study conducted by Flynn & Flynn (2005), the notion of co-makership was noted as a contributing factor to reduced lead times and improved quality. Further, Flynn & Flynn (2005) found that a higher degree of formalization proves increasingly beneficial and may diminish the need for inspecting incoming items.

A collaborative process central to the automotive industry is the Production Part Approval Process (PPAP) and its phased variant developed by Ford (2002) (AIAG, 2006).

2.2.3.1 Production Part Approval Process

PPAP is a quality assurance process that strives to verify the conformance of suppliers for new products as well as modified products (AIAG, 2006). Through buyer-defined requirements and supplier conformance, PPAP acts as a collaborative inspection process where both parties can communicate.

PPAP consists of 18 distinct, interrelated elements that collectively validate all aspects of a component and its production process, from materials to tooling (Gawlik et al., 2012). These elements are listed in *Table 1* and further elaborated on in *Appendix B*. The central element of PPAP is the Part Submission Warrant (PSW), a formal declaration from the supplier that all customer requirements have been met and that the submitted parts are representative of the production intent (Gawlik et al., 2012).

Table 1 – The PPAP Elements

Element	Description
(1) Design Record	Blueprint detailing dimensions, materials, and tolerances
(2) Engineering Change Document	Proof of approved changes not in the original design
(3) Customer Engineering Approval	Evidence of buyer's technical approval
(4) Design Failure Mode and Effects Analysis	Risk analysis to prevent design-related failures
(5) Process Flow Diagrams	Overview of the production steps
(6) Process Failure Mode and Effects Analysis	Risk analysis of the manufacturing process
(7) Control Plan	Document defining methods for process control
(8) Measurement System Analysis Studies	Validation of measurement system capability
(9) Dimensional Results	Evidence of compliance with design dimensions
(10) Material, Performance Test Results	Documentation of test outcomes
(11) Initial Process Studies	Proof of process stability and capability
(12) Qualified Laboratory Documentation	Proof that lab used is qualified for the tests
(13) Appearance Approval Report	Verification of parts' aesthetic requirements
(14) Product Sample	Physical samples for buyer evaluation
(15) Master Sample	Reference part approved by the buyer
(16) Checking Aids	Measurement tools used, validated via MSA.
(17) Customer-Specific Requirements	Proof of compliance with buyer-specific demands
(18) Part Submission Warrant	Formal declaration that all requirements are met

For PPAP, there are five submission levels that dictate the extent of documentation and approval required before parts can be used in manufacturing. These submission levels are determined by factors such as the criticality of the component, the complexity of the part, the history of the supplier, and the nature of the supplier-buyer relationship. As per AIAG recommendations, PPAP level three is considered the default submission level unless a buyer representative grants authorization for a different level (AIAG, 2006). The different levels are described in *Figure 4*.

<i>Submission Level</i>	<i>Requirements</i>
<i>Level 1</i>	PSW only (items with appearance requirements also need an Appearance Approval Report)
<i>Level 2</i>	PSW with product samples and limited supporting data
<i>Level 3</i>	PSW with product samples and complete supporting data
<i>Level 4</i>	PSW and other customer-defined requirements
<i>Level 5</i>	PSW with product samples and complete supporting data reviewed at manufacturing location

Figure 4 – The Submission Levels of PPAP

2.2.3.1.1 Phased PPAP

A variant of PPAP is the phased PPAP, developed by Ford (2002). Through dividing the 18 elements into three sequential phases – *Quality Verification*, *Production Verification* and *Capacity Verification*, both suppliers and OEMs are expected to benefit from clarity in the PPAP as well as having more manageable segments (Ford, 2002).

Prior to the first phase, suppliers need to perform an initial Run at Rate (R@R) with a setup that resembles final production (Ford, 2002). The R@R provides an early indicator whether suppliers can produce the required capacity and quality in line with buyer requirements. Typically, buyers require a minimum of 300 pieces for the R@R produced within a production run of one to eight hours (Ford, 2002). A buyer-approved R@R is needed for transfer to phase one, as a satisfactory R@R is crucial for validating supplier readiness.

Phase one, quality verification, encompasses dimensional verification and engineering specification testing, incorporating 15 of the 18 PPAP elements (Ford, 2002). By testing the parts produced during the R@R, suppliers validate their conformance to buyer-requirements in terms of tolerances and processes. During the second phase, production verification, suppliers must complete all PPAP elements in line with AIAG guidelines (Ford, 2002). Here, suppliers need to validate the final production setup through verifying dimensions as well as part appearance. The final phase of the phased PPAP is capacity verification, in which the supplier needs to demonstrate that their manufacturing setup can produce quality parts with a capacity that meets a minimum of one day daily production (Ford, 2002). This step ensures that the supplier's processes are stable, repeatable, and capable of supporting ongoing production volumes before full approval is granted by the OEM.

2.2.4 Identified practices

Based on the previous sections, *Table 2* summarizes the identified practices of improving SQM. By dividing the practices per area and source, unique and overlapping practices may be identified.

Table 2 – Practices for Improving Supplier Quality Management

Area	Suggested Practices
Inspection	<p>Early defect detection, resource allocation & visibility of material flows (Lee & Li, 2018)</p> <p>Risk assessment models, strategies for defect item management & rigid inspection procedures (Attia, 2024)</p> <p>PPAP & phased PPAP (AIAG, 2006; Ford, 2002)</p>
Investment	<p>Quality Management Systems, improvement in production processes & use of high-quality tools and materials (Lee & Li, 2018)</p> <p>Capital resources and equipment, shared savings & collaboration as a complement to investment (Bai & Sarkis, 2016)</p>
Collaboration	<p>Training in lean production and quality management (Lee & Li, 2018)</p> <p>Sharing long-term goals, Intensive communication, early involvement in product and process development (Noshad & Awasthi, 2015)</p> <p>High degree of formalization (Flynn & Flynn, 2005)</p> <p>Sharing of technology and information, compatible Information Systems (Chin et al., 2006)</p> <p>PPAP & phased PPAP (AIAG, 2006; Ford, 2002)</p> <p>Real-time communication, information sharing, aligning goals & system cost reduction over individual (Attia, 2024)</p>

To assess the capabilities of an organization's quality and supplier quality processes, Capability Maturity Model Integration (CMMI), can be a feasible way.

2.3 Capability Maturity Model Integration

CMMI is a process improvement framework developed by the Software Engineering Institute (SEI) at Carnegie Mellon University. Initially, the framework was intended for software improvement but has evolved to be a valuable tool for organizations in several industries, serving both service- and product-oriented companies (CMMI Institute, n.d). Through systematically dividing the processes of a corporation into capability levels, maturity levels and performance areas, Chrissis et al. (2011) state that CMMI serves as a comprehensive framework for diagnosing and improving companies. In a study conducted by Ho et al. (2016), a framework was developed to aid organizations in assessing their supply chain collaboration capabilities, highlighting the compatibility between SQM and CMMI.

CMMI can be applied using either staged or continuous representation, depending on the aim of the usage. While staged representation uses maturity levels to assess the overall state of an organization's processes, the continuous representation uses capability levels to characterize the state of organizational processes in relation to an individual process area (Chrissis et al., 2011). As APQP and PPAP do not

comprehensively encompass the QM of an organization, continuous representation is more applicable. The following sections define the key performance areas, the capability levels and their relation to APQP and PPAP.

2.3.1 Key Performance Areas

To cover the fundamental areas of process improvement, the CMMI model encompasses 16 core process areas, covering vital processes such as acquisition, development and services (Chrissis et al., 2011). The specific model of Chrissis et al. (2011) states 22 areas, however not all performance areas are needed for analysis of SQM due to the broad nature of the framework. Instead, the components relevant to the case at hand should be applied. In the specific case of APQP and PPAP, the relevant key performance areas are identified in *Table 3*. Using these areas allows for pinpointing the improvement potential in line with the empirical data. Out of the four denoted performance areas, *project planning (PP)*, *organizational process definition (OPD)* and *organizational training (OT)* are considered critical for project and process management success according to Huang & Han (2006). In this study, Huang & Han (2006) reached this conclusion by asking senior software managers and consultants which process areas they found critical in their work. Furthermore, these areas were chosen for their relevance to APQP and PPAP. Together, they represent foundational aspects for managing cross-functional collaboration (IPM), establishing standardized work practices (PP, OPD), and fostering competence development (OT) - factors that are essential for the effective implementation of APQP and PPAP (Chrissis et al., 2011; Stamatis, 2018).

Table 3 – Chosen Key Performance Areas

Category	Area	Definition	Relevance
Project Management	Project Planning (PP)	Establishes and maintains plans that define project activities, timelines, resources, and commitments.	Supports structured APQP and PPAP phase planning, timelines, milestones, and responsibilities
	Integrated Project Management (IPM)	Manages the project and its processes in a coordinated and integrated way, ensuring alignment with organizational goals and stakeholders.	Relevant for cross-functional integration and coordination across organization and suppliers
Process Management	Organizational Process Definition (OPD)	Develops and maintains a usable set of organizational process assets, including standards, procedures, and templates.	Supports routine processes connected to APQP and PPAP such as documentation and ways of working
	Organizational Training (OT)	Ensure individuals have the necessary knowledge and skills to perform their roles effectively through structured training programs.	Supports capability development across functions and roles, such as training and knowledge management connected to APQP and PPAP

2.3.2 Capability Levels

The capability levels of CMMI range from 0 – 3 (incomplete to defined) and are related to individual practice areas (Chrissis et al., 2011). The levels are cumulative as each level adds new functionality or rigor. While there are generic practices that need to be fulfilled for each capability level, there are also specific practice areas to satisfy, which depend on the performance area at hand (Huang & Han, 2006). An example of a general practice is “Plan the process” (Chrissis et al., 2011) which can be applied to several process areas, while an example of a specific practice is “Manage stakeholder involvement” (Chrissis et al., 2011), which is attributed to IPM. Below in *Figure 5* are the general characteristics of the four levels, as defined by Chrissis et al. (2011).

<p><i>Capability Level 0: Incomplete</i> An incomplete process is either partially performed or not performed at all. The goals of the process are not satisfied and moving forward encompasses performing the process.</p>	<p><i>Capability Level 1: Performed</i> A level one process is a performed process that does the necessary work to produce what is needed. Although improvements can be made at level one, these are not always made part of the organizational procedures.</p>
<p><i>Capability Level 2: Managed</i> A managed process is a performed process that is planned and executed in accordance with policy. Skilled people that have adequate resources are employed to produce controlled outputs, relevant stakeholders are involved, and the process is monitored, controlled, reviewed and evaluated in line with its description. The discipline of level two ensures that organizations apply existing practices despite stressful times.</p>	<p><i>Capability Level 3: Defined</i> A defined process is a performed process tailored to be in line with the overall organizational standards. In addition to a managed process, the defined process ensures that practices are consistent despite project variation. Furthermore, the processes at capability level three are typically more rigorously defined and managed more proactively.</p>

Figure 5 – The Capability Levels of Continuous CMMI

Advancing between capability levels requires the application of either the generic practices as outlined by Chrissis et al. (2011) or suitable alternatives. Reaching a higher capability level means satisfying the specific requirements, such as moving from level zero to one encompasses processes that are completed within the performance area.

2.4 Relevance and Application of Framework

As structured methodologies for quality assurance in product development, APQP and PPAP are fundamentally linked to the principles of QM. Given that APQP functions as a project-oriented approach, the inclusion of frameworks such as PDCA, Triple Constraint, and FTR provides relevant tools to assess project management behaviors, trade-offs, and up-stream accountability. Moreover, since both APQP and PPAP depend on supplier collaboration, applying SQM theory introduces a necessary external perspective for evaluating coordination and performance across organizational boundaries.

The relevance of CMMI in this thesis lies in its ability to assess process maturity in a structured and systematic way. By providing a framework for evaluating the current state of APQP and PPAP practices, CMMI enables the identification of organizational

gaps and supports the formulation of targeted improvement areas. While the full CMMI framework includes a wide range of process areas, this thesis applies a focused subset relevant to the evaluation of APQP and PPAP practices. This selective approach follows the modular nature of CMMI and aligns with the case-specific scope of the study (Chrissis et al., 2011). Process areas were chosen based on their relevance to the key themes identified in the empirical data.

While QM and SQM theory were applied to analyze the current processes both internally and externally, the CMMI framework was used to structure the analysis and identify organizational gaps. The combination of QM, SQM and CMMI was applied to formulate actionable suggestions. While it was noted that there are newer versions of CMMI, this study applies a previous version due to its clear definitions of process areas and capability levels.

3. Method

This chapter covers the chosen methodological approach adopted throughout the research. It initially discusses the choices of research strategy and design approach which is followed by an elaboration of data-collection method and analysis. Finally, it covers discussion of research quality and ends with the ethical consideration that were made during the research.

3.1 Research Strategy & Approach

The choice of a suitable research strategy can be divided into two main approaches, quantitative or qualitative research (Bell et al., 2019). Quantitative research is applied when the research intends to emphasize quantification, which builds upon a deductive approach using predefined theories that are assumed to be true or false. The research thereafter builds upon quantification of data to test the relationship between theory and research to conclude a result. In contrast, qualitative research generally follows an inductive approach where presumed theories do not exist. Instead, the emphasis lies on the generation or development of new theories through qualitative evidence that may be found (Bell et al., 2019).

For this research, a qualitative approach was decided on with the motivation lying in the exploratory nature of the study. It was also motivated by the given circumstances of this research where prior investigation in the subjected field were scarce. This highlighted a need to explore in-depth practices before unfolding new theories, in which a qualitative approach was seen appropriate. In addition, literature review indicated that existing research in the field was limited, thus lowering the feasibility of a deductive approach.

As explained by Bell et al. (2019), grounded theory through empirical data commonly follows an inductive approach, however such approach infers limitations in the output of novel theory (Timmermans & Tavory, 2012). In the opposite case, deductive research can't facilitate new theory generation as it is biased from the process of validating input towards the theory that is derived in the beginning of the research (Timmermans & Tavory, 2012). Addressing these limitations may be done using a third approach referred to as abductive reasoning. The process, which builds on a puzzle-solving dynamic approach (Bell et al., 2019), emphasizes an iterative approach of engaging with existing theories alongside new empirical data to derive a theory of novelty (Timmermans & Tavory, 2012). In this context the study began with initial hypotheses and assumptions provided by the key informants. Thereafter qualitative interviews enabled an iterative approach to derive additional findings rather than solely seeking to validate the initial theories.

3.2 Research Design

As Bell et al. (2019) explain, research design defines a structured framework for collecting and analyzing data which should reflect the choice of criteria for evaluating the quality of research findings. Within qualitative research, case study research designs distinguish from other research designs in that they focus on a bounded situation or system such as an organization or location (Bell et al., 2019). When addressing the issue of "how", the case study is an effective method that provides usage of multiple data sources, enabling triangulation, while also enhancing in-depth understanding of real-world context (Yin, 2014).

From this reasoning the choice of a company specific case study design was deemed most suitable. Given that the application of APQP and PPAP often varies between companies, focusing on the internal organizational perspective also allowed

for a more context-specific understanding. While this may lower the generalizability of the findings it strengthens the practical relevance and provides a deep understanding of how APQP and PPAP is applied in the case specific context. However, an internal perspective has led to the perspective of suppliers not being directly considered. Instead, the interaction with suppliers has rather been captured from the perspective of different employees working with them.

3.3 Sampling

The selection of the case company was guided by its relevance to the research purpose. With active involvement in both APQP and PPAP processes, the chosen OEM presented a suitable context for investigating the research questions, thus motivating the choice. Moreover, since internal functions at the OEM had already expressed a need to improve these processes, the selection helped increase the likelihood of active engagement with the study, as well as a willingness to contribute time, insights, and resources.

The interviewee sampling criteria focused on individuals actively involved in the subject area, which included a cross-functional group comprising SQM, logistics, procurement, R&D and digital. For the sampling quantity, a greater number of interviewees were chosen from the division of SQM, as these were judged more invested in the topic due to higher involvement.

The selection of interviewees was approached using a mix of purposive sampling methods. In qualitative analysis the non-probability purposive sampling enables a wide range of sampling methods and becomes particularly useful when the research wishes to target any critical subgroups within the research sample (Neetij & Bikash Thapa, 2004). Primarily the purposive sampling sought people with expertise to assure the answers would be nuanced. The use of key informants as a bridge facilitated quick contact with the initial interviewees and ensured a higher willingness to participate. In addition, asking interviewees for further participants (referred to as snowball sampling) became helpful in reaching “hard-to-reach” populations (Bell et al., 2019). Getting further participants through snowball sampling helped decrease the risk of bias from using interviewees solely suggested by the key informants.

3.4 Data collection

The data collected throughout the study stems from key informants, observations, document studies and interviews. These methods will be further discussed in this section.

3.4.1 Key informants

Marshall (1996) quick access to rich and detailed data. However, Marshall (1996) also pinpoints that the usefulness of information gained will depend on certain characteristics of the key informants including the relevance of their role, their knowledge and willingness to communicate. In this research, two key informants were chosen from the division of SQM. Due to SQM’s central role in APQP and PPAP, it was judged that this function would be suitable. Having two key informants with different positions rather than one has diversified the risks of bias and benefited the validation of findings to enhance its credibility.

Throughout the research, being situated in the same office as the key informants has allowed regular and informal interactions. This was seen as significantly beneficial in the beginning of the research when our understanding of APQP and PPAP was limited.

3.4.2 Document Studies

The document studies in this research have followed an iterative approach used at multiple stages of the research in which key informants have had a significant role in providing company material. To support contextual understanding, initial document analysis was carried out, focusing on company-specific sources. These included training materials, internal IT system documentation, and detailed records outlining how APQP and PPAP are structured and applied within the organization. Later use of document studies served a purpose of validating findings and further increasing understanding within specific areas. As highlighted by Bowen (2009), document analysis is a valuable tool for validating findings from other sources, a process referred to as triangulation. While Bowen (2009) further defines the various use-cases of document analysis, he also underlines that document analysis should not be used in isolation, but rather in combination with further data sources such as interviews.

3.4.3 Interviews

The interview format followed a semi-structured approach using a general template of predefined questions as guidance to assure each interview would cover all critical areas, see *Appendix C*. A total number of 12 interviews were conducted in line with *Table 5*, one of which was a follow-up interview. The interviews averaged a length of 60 minutes where both interviewers were present. Each interview was initiated with an explanation of confidentiality to assure respondent could fully express their thought, followed by a question on consent to record each session ensuring a high-quality uninterrupted discussion. This approach allowed transcription to be made afterwards where sensitive data was anonymized before further usage. Having an open-ended format allowed respondents to share in-depth insights from their own perspectives, while the structured elements ensured consistency across interviews, supporting comparability and potential generalization of findings.

Despite semi-structured approach being common in qualitative analysis, Bell et al. (2019) note that semi-structured interviews also puts a higher emphasis on how the interviewer responds in which the quality also becomes dependent of follow-up questions from the interviewee. The ability to reply with off-script questions, known as probing, provides flexibility to an otherwise structured approach, which helps to highlight relevance and importance from the perspective of the participants (Bell et al., 2019). Moreover, it helped interviewees develop nuanced answers and enabled the interviews to be steered back to the central themes when interviewees started to go off-topic. As highlighted by Robinson (2023), probing has an ability to turn generic responses to specific memories that helps to extract rich and detailed information of specific events.

Table 5 - Interviewee List

Title	Notation	Function	Medium
Senior SQM Manager	S1	SQM	Video
Senior SQM Engineer	S2	SQM	Face-to-face
Solution Architect	D1	Digital	Face-to-face
Buyer Battery Cell and Module	P1	Procurement	Face-to-face
Buyer Electric Motor & Transmission	P2	Procurement	Face-to-face
Lead Engineer Battery Cell and Module	R1	R&D	Face-to-face
Supply Chain Management Project Engineer	L1	Logistics	Face-to-face

Logistics Programs & Operations Manager	L2	Logistics	Face-to-face (2 occasions)
Vehicle Hardware Battery Design & Testing	R2	R&D	Face-to-face
SQM Structure/Interior	S3	SQM	Video
SQM Exterior/Chassis	S4	SQM	Video

3.5 Data Analysis

When analyzing qualitative data, Bell et al. (2019) highlight the value of thematic analysis, which involves identifying and interpreting themes and patterns across a dataset. Patterns can be found through repetitions, similarities and differences, or theory-related content. However, Bell et al. (2019) note that a pattern alone is not always enough to define a theme, as its relevance to the research questions is what determines its significance.

In this study, analyzing data was done using thematic analysis on the transcribed interview data. The first step involved manually extracting the key findings from transcriptions with the purpose of clarifying the data. Thereafter the qualitative data was derived into categories using thematic coding to identify reoccurring codes and themes, as seen in *Table 6*.

Table 6 – Examples of how Thematic Analysis was Performed

Quote	Code	Theme
“It would make more sense if it would be more automated.”	Automation	IT System
“... it could be made smarter if the different systems communicated with each other. If they would, we would not need to manually update and go through the status ourselves”	Back-end Connectivity	
“The APQP application we are not looking into at all I would say”	System Access	Involvement
“... as a buyer here, we are not traveling a lot. So, most of the guys here just see contracts or presentations, but you’re not going in the suppliers to see how it’s working in the process. So, this is the thing, it’s missing a lot here.”	Supplier Interaction	

3.6 Research Quality

When considering the quality of qualitative research, (Bell et al., 2019) propose the four principles of credibility, transferability, dependability, and confirmability. This research took accountability for each of them in ways that are motivated separately below and summarized in *Table 7*.

The use of *credibility* applies to addressing how well the findings reflect participants perspective in research, which is particularly important when multiple interpretations of the same social reality exist Bell et al. (2019). According to Bell et al. (2019) it connects to qualitative research due to its subjective characteristics which often entail more than one correct answer. Thus, the trustworthiness of the research becomes reliant on the degree of accuracy that has been taken by the researchers to interpret the words of its participants. In this research transparency of interviews has been assured using digital tools to aid the process of documentation. Using voice-recording during the interviews has contributed to preserving detailed wording of what each participant has expressed while also benefiting the probing quality through active listening. After the interview, an AI-based voice transcription tool ensured fast and accurate documentation. The transcripts were then manually reviewed to address any errors made with the AI-tool. As the tool marked timestamps it allowed for a smooth process of proactively reviewing interview material to fully comprehend the participants' results.

The *transferability* of qualitative research aims at discussing the depth and detailed insight that the research gives to a certain context. Bell et al. (2019) highlight Geertz's concept of "*thick description*", which entails providing rich and detailed descriptions of cultural or social settings of the context, to support transferability and allow readers to determine whether findings may apply to other contexts. As this research is built upon a company-specific setting it may prove difficult to execute a similar approach in another setting. However, by adopting the consideration of thick description, this research has aimed to provide a rich and detailed description of the organization and the contextual settings including processes and structures. Additionally, throughout the research, direct employee quotations have primarily been used to enrich and support the contextual depth of the descriptions.

Ensuring that research findings reflect the data and not the researchers' personal beliefs is important for the *confirmability* of the research. As research may struggle to adopt full objectivity it necessitates transparency and grounded evidence that motivates the decisions taken throughout research (Bell et al., 2019). For confirmability the documentation of transcribed material retained a detailed structure to not lose the original content. Thus, the master documents used for further coding themes consisted of detailed summarized documents for each interview capturing key statements, insights, and citations. Further validating the results using the key informants has helped to strengthen an unbiased perspective and trustworthy findings.

By staying consistent in the research process, it ensures the readers of a stable, traceable, and repeatable approach, enhancing its *dependability*. Having a well-thought-out choice of research method, adapted to the organizational settings, has ensured that the research could be followed with consistency and in chronological order. From the perspective of dependability, it is however necessary to enlighten that this research took advantage of probing to derive parts of the key findings. Thus, an attempt to repeat this approach may not prove to be effective due to probing

quality relying on the ability of the researcher. As Yin (2014) suggests, a case study design serves as an effective method for research but links to the researcher's ability.

Table 7 – The Four Research Quality Principles and Their Contextual Application

Criteria	Definition	Application in the Research
Credibility	Refers to how accurately the researcher interprets participants' meanings and experiences (Bell et al., 2019).	<ul style="list-style-type: none"> • Voice-recording of interviews to capture accurate expressions. • Use of AI transcription tool for fast and precise documentation. • Manual review of transcripts for error correction. • Timestamps allowed efficient cross-checking and in-depth understanding
Transferability	Regards whether findings can apply to other contexts. Supported by thick description (Bell, 2019).	<ul style="list-style-type: none"> • Detailed contextual descriptions of the organization, its processes, and structures. • Rich insight into the setting allows readers to assess applicability elsewhere.
Confirmability	Focuses on ensuring findings are shaped by the data and not researcher bias (Bell et al., 2019)	<ul style="list-style-type: none"> • Structured documentation of transcribed material. • Summarized documents with key insights, quotes, and statements. • Validation of findings with the supervisor to ensure unbiased results.
Dependability	Refers to the stability and consistency of the research process (Yin, 2014).	<ul style="list-style-type: none"> • Methodical and chronological research approach. • Adaptation to the organizational context. • Probing techniques contributed to insights but are dependent on researcher skill.

3.6.1 Use of Generative AI

In writing the paper, generative AI has been used to aid language, grammar and sentencing. Using generative AI has allowed for ensuring better readability and flow of the thesis. Throughout the usage, effort has been put into making sure that the core information has not been lost and that all information stems from collected data, and not from the language model.

3.7 Ethical Considerations

According to (Bell et al., 2019), the four ethical considerations a researcher is expected to follow consist of avoidance of harm, obtaining informed consent, protection of privacy through confidentiality, and preventing deception. In this research, ethical practices were primarily focused on participants involved in data collection as well as the protection of company-sensitive information. Prior to conducting interviews, participants were informed about the purpose of the study and asked consent to record the interview to ensure voluntary participation. Thereafter, to prevent harming participants' identities, all data was anonymized before being used in analysis or presented in the findings. To protect the company's privacy, it has been anonymized in this report and sensitive data has been excluded.

4. Empirical Results

The findings of this study are divided into two parts. The first part describes how APQP and PPAP are applied at the OEM through information gained during interviews, document studies and from key informants. The second part builds upon information gained from the interviews as well as the key informants and focuses on the challenges and improvement areas of the current processes.

4.1 Part I: APQP and PPAP at the OEM

In this section, APQP and PPAP will be presented in the context of the OEM. Through describing the overall structure, processes, IT system, employee- and supplier responsibilities, company-specific insight is presented. According to several SQM employees, PPAP is considered a subprocess to APQP since several tasks performed in APQP also regard PPAP elements. Therefore, findings regarding APQP are presented first, followed by PPAP and lastly the relation between the two.

4.1.1 APQP

APQP is seen as a planning process that takes a holistic view on quality assurance through incorporating the perspective of several stakeholders, one SQM employee expressed. This viewpoint was also stated by an SQM manager who further emphasized that APQP is foundationally a standardized work approach that enables company certification. Several interviewees highlighted that the internal APQP process is adapted from another OEM which the company is an affiliate of. Today, the company generally applies two approaches to APQP – digitally driven or driven through excel. In an interview with an R&D employee, this was exemplified as the individual used excel for conducting APQP. The digital approach involves using an internal APQP application, which is used by both employees and suppliers.

4.1.1.1 The Digital APQP Application

As a tool for standardizing the use of APQP, the OEM has adapted an application. Consistent with the OEM's APQP process, the digital application also follows the design principles established by the affiliate OEM. In this application, both employees and suppliers can keep track of the APQP progress, allowing for documentation, commenting and checking off finished tasks. According to a solution architect, the application itself is connected to the overall system architecture that stores order and product information, allowing for automatic information transfer. The application incorporates the OEM's approach to APQP, encompassing maturity levels over phases and deliverables for further structuring.

4.1.1.2 From Phases to Maturity Levels

Instead of using the five general APQP phases as defined by AIAG, the company divides the project into maturity levels. Each of these maturity levels encompasses the completion of a milestone, allowing the project to be divided into measurable checkpoints. The purpose of having checkpoints is to allow for a gated process, in which completion of prior levels is needed to progress. In the planning phase of APQP, the supplier and OEM decide upon the timing of each checkpoint, meaning when it should be completed. As some of the phases encompass the creation of a prototype either to validate tooling or geometry, there are also set deadlines for when materials are required at the build site to enable prototyping.

4.1.1.3 Deliverables

While APQP is divided into maturity levels, the maturity levels are divided into deliverables, as conceptually seen in *Figure 6*. A deliverable can be seen as a task or procedure that needs to be performed to satisfy the related milestone. Since APQP is

a general framework that is applied regardless of whether a screw or car seat is developed, the extent of applicable deliverables varies between components, according to an SQM employee. Therefore, the planning phase of APQP includes deciding what deliverables are applicable. One aspect that varies the extent of APQP deliverables is whether the component has appearance requirements, such as a steering wheel. These components have more requirements as their appearance needs to be tested and approved, encompassing further deliverables. Furthermore, as PPAP is treated as a subprocess of APQP, some deliverables are explicitly designed to support the validation of PPAP elements, particularly in later maturity levels.

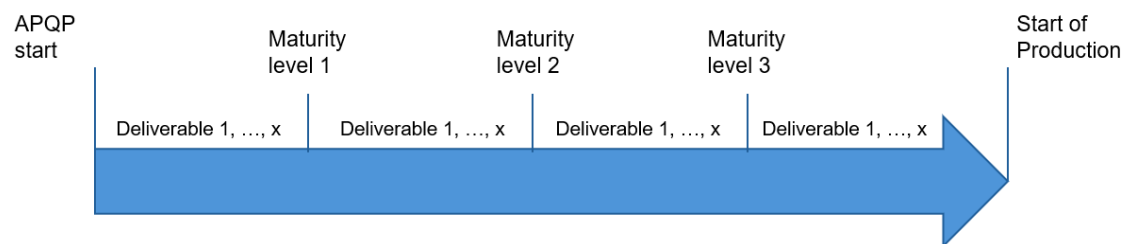


Figure 6 – General Illustration of Maturity Levels and Deliverables

4.1.1.4 Supplier Responsibility

A general understanding of supplier responsibility is that while suppliers are responsible for conducting testing, planning production, and verifying capacity, the OEM is tasked with verifying that these activities meet performance expectations. Furthermore, suppliers are responsible for ensuring that sub-suppliers also follow the OEM's guidelines. The degree of supplier responsibility varies depending on the specific component. As an SQM manager explained, the responsibility for conducting tasks such as DFMEA is determined by design ownership. When the design is created in-house, the OEM assumes responsibility for design-related deliverables. Conversely, if the design is owned by the supplier, it is the supplier who must fulfill the corresponding deliverables. Furthermore, the supplier assigns a cross-functional team, where a supplier lead is responsible for communicating and documenting performance and compliance towards the OEM.

4.1.1.5 The Responsibility of Functions

From an internal perspective, the four functions directly involved in APQP are logistics, procurement, R&D, and SQM. Although APQP is a cross-functional process in which various departments work together to ensure overall performance, the deliverables are formally assigned to specific functions. The ownership of these deliverables depends on both the maturity level and the type of component, which necessitates a formal handover between functions when ownership changes. In the APQP application, this handover is visually represented by a green mark that signals completion. According to an SQM employee, the involvement of functions towards APQP can be divided into three levels, where SQM and R&D make up level one, logistics level two and procurement level three. Using these levels as a guide, the presentation of functions will be made bottom-up, from least involvement to most.

As validated by a buyer, the involvement of procurement is limited. Initially, the buyer sets up the contract with the supplier which encompasses "... *the contract between us and the supplier, where we have the volume, the design, the prices, everything, all the different guidelines*" (P1). In line with this, an SQM employee and another buyer highlighted that buyers are more involved in the initial phase of APQP. According to

one buyer, the most vital deliverables of procurement are regarding purchase orders (PO) and tool orders. *“The main inputs requested in the APQP for the buyer is regarding POs. Are the POs out? Yes, no. Is the agreement signed? Yes, no. And that’s pretty much it”* (P2). As the OEM invests in the required tooling of suppliers, buyers are responsible for ensuring that suppliers are eligible to get paid. In addition to contracts, purchase orders and tool orders, buyers are involved in resolving issues with suppliers. *“So often when there is a problem, when there is something to highlight, to escalate, then the buyer is involved and is supporting.”* (P2).

The logistics function is responsible for the packaging and transportation of components, as explained by a logistics manager and verified by an SQM engineer. According to a logistics manager, the extent to which the logistics function is involved in APQP is smaller than stated in the internal documentation, because the supplier logistics assurance (SLA) function is outsourced. According to an SQM engineer when discussing the involvement of logistics: *“from an APQP perspective we require that the packaging is approved, tested and complete. That there is nothing wrong with it and that the product that is delivered will not be damaged. This, they (logistics) need to assure in some way”* (S2). A logistics manager explained that there are two types of packaging that they manage - standard packaging concerning pallets and boxes, and special packaging concerning other solutions. In collaboration with part suppliers, logistics discuss possible packaging solutions: *“...and then we send that these are the sizes available, and then we discuss this with the supplier, and they come with a suggestion”* (L2). Further, the manager states that the supplier lead is responsible for documenting information in the APQP application, as they are responsible for sending packaging instructions.

According to an SQM employee, Research and Development (R&D) are responsible for the component/part. As further added by an R&D employee, the extent to which R&D is involved depends on the component ownership. If the supplier owns the design, they are responsible for most of the deliverables, such as DFMEA. According to two R&D employees, the conducting of APQP varies depending on the supplier and SQM employee. Overall, both employees highlighted that their approach to APQP is reactive, and that SQM is driving progress. In the early phases of APQP, R&D ensures amongst other things that the component will fit. At a later stage, R&D are responsible for design changes made to the component. As explained by one employee: *“... we can make the design as fancy and extreme as we want. But if it’s not cost efficient, then it’s not going to fly”* (R1). Furthermore, R&D are involved in resolving quality issues with the supplier, such as deviating performance values.

As highlighted by several employees and verified by internal documentation, the division of SQM is most involved in APQP. As described by one employee, SQM are responsible for the manufacturing site of the suppliers, ensuring that it is ready to produce the products that R&D are responsible for. Looking at the combined deliverable ownership of R&D and SQM, it can be concluded that these two functions collectively own most of them and that SQM are assigned to more deliverables than R&D. Furthermore, some tasks owned by other functions are performed in collaboration with SQM employees. Examples of these are packaging evaluation, tooling orders and escalations. In addition to a large deliverable ownership, SQM are responsible for conducting cross-functional APQP meetings together with employees and suppliers, to ensure that questions and problems are resolved. In *Table 8*, an overview of the responsibilities per function is presented.

Table 8 – Summary of Responsibilities in APQP per Function

Function	Involvement level	General responsibility	Additional responsibilities
SQM	1	The supplier manufacturing plant	Ensuring progress, conducting APQP meetings
R&D	1	The component	Main collaborator of SQM, ensuring component quality and design
Procurement	3	Contracts and orders	Supporting the other functions, helping with escalations
Logistics	2	Packaging and transportation of components	Supporting SQM, communication with SLA

4.1.2 PPAP

Currently, the OEM ensures compliance with AIAG guidelines by following the standardized PPAP approach, which is considered mandatory due to regulatory necessity. Since the theoretical foundation of PPAP has already been outlined in the theoretical framework, this subsection focuses on how PPAP is implemented and interpreted in practice at the OEM. Initial discussion will follow how the OEM structures the PPAP phases and how it is incorporated in the system. Thereafter involvement will be discussed, seen from the supplier and from the cross-functional departments. Finally, the relationship between PPAP and APQP will explain how the OEM views these two processes.

4.1.2.1 PPAP Phases

The OEM currently structures the PPAP process into three defined phases - *Quality Verification*, *Production Verification* and *Capacity Verification*, using a framework like the phased PPAP of (Ford, 2002). Prior to the first phase, the OEM performs a R@R audit which is commonly done independently by the SQM. From the R@R the OEM selects produced parts to be reviewed and tested for sequential phase approval. Additionally, if suppliers use multiple production lines to produce a part, the second phase is further divided into two sub-phases to clarify the timelines for readiness. For such cases the first sub-phase addresses the requirements of the main production line, while the latter sub-phase ensures the alignment of all production lines. The OEM incorporates the PPAP elements according to the standard, complementing it with company and part-specific documents that aim to maintain agreement between the OEM and the supplier. Throughout the phases, PPAP elements are progressively addressed where completion of each phase comprises a submission that requires certain elements to be fulfilled before passing to the next phase. The submission level of readiness is either level 3 or 5 but varies with part complexity and criticality, and between suppliers. The last submission level comprises the Part Submission Warrant (PSW), which requires completion of all elements as well as on-site auditing, and serves a legal document and formal approval of the part.

4.1.2.2 PPAP Application

To formally track and report PPAP progress, employees use the OEM's in-house PPAP application. The application is shared between suppliers and the OEM with intended use for suppliers to input PPAP related information that may be validated by the OEM to ensure alignment of established requirements and timelines.

The application is structured for each project where every unique part has its own subfolder. For each part the main element is the official PSW document. Further it contains a checklist of the PPAP elements which encompasses sub-criteria for each element, allowing the supplier to upload documents and update the progress of the PPAP on a detailed level. Moreover, additional information in the PPAP application includes team member information and part-specific information from attachments, that is filled in throughout the PPAP process.

4.1.2.3 Supplier Involvement in PPAP

The supplier involvement in PPAP primarily centers on reporting to the OEM as the process progresses. For each of the suppliers, the supplier lead is normally selected to be responsible for reporting. This role will be engaged with the OEM on a frequent basis through mail and meetings. The supplier is also responsible for reporting on certain PPAP dates in the PPAP application and complying with OEM requirements, which may include verifying that sub-supplier processes meet the OEM requirement and quality standards.

4.1.2.3 Functional involvement in PPAP

The employee's involvement in PPAP varies between the functions. Least involvement is seen in the function of logistics who consider themselves to not be involved in PPAP.

Employees at procurement state that daily activities have an impact on the PPAP results where responsibility includes ensuring reactivity from supplier and follow up on errands such as when an issue requires escalation. However, it is noted that their involvement comes indirectly through daily interaction with the SQM who has an overview of the PPAP progress, and contacts procurement when support is needed. Thus, both procurement interviewees confirm no interaction with the PPAP application.

Within the respective functions of R&D and SQM, PPAP involvement is notably higher, with formal responsibility for the 18 core PPAP elements currently divided between the two based on the nature of the deliverable which is either process-oriented or design-oriented. Elements that occur in the earlier phases, typically more design-oriented, are primarily led by R&D, while those in the later stages fall under the responsibility of SQM. According to an R&D employee, their function are heavily involved in PPAP during the first phase. However, the employee claims that ownership of PPAP progression and its gates belongs to SQM, where R&D's role is to support them. Validation from SQM confirms their high involvement in PPAP. As the process progresses, it is also noted that SQM gradually takes over responsibility for the completed PPAP elements initially led by R&D which helps the process if any backtracking is needed.

4.1.2.4 The relation of APQP & PPAP

Currently, the OEM has a vision of using APQP as an independent, full-scale, cross-functional process that leads to the Part Submission Warrant (PSW), as emphasized by interviewee S1. As part of this, compliance with PPAP is met by integrating PPAP elements into the APQP deliverables. This approach positions PPAP as a subprocess of APQP where the criteria for each PPAP element is gradually completed by one or more deliverables as the APQP milestones progress. However, PPAP and APQP are currently handled through two separate applications. This setup stems from the fact that APQP was originally adopted from the affiliate OEM, while

PPAP was developed internally. At this point, no effort has been made to integrate them. Additionally, the legal requirements tied to PSW further mean that PPAP is handled in a distinct document so that it may be handled as a final approval document.

Figure 7 provides an illustration of how APQP and PPAP correlate in timing. As intended by the OEM, APQP should be the main process for industrialization of a product where PPAP is a parallel subprocess. Thus, the APQP events are used to set timing of the PPAP phases. However, the illustration only provides a figurative depiction meaning that accuracy and ratios of the illustration do not depict a representation of the OEM's actual processes.

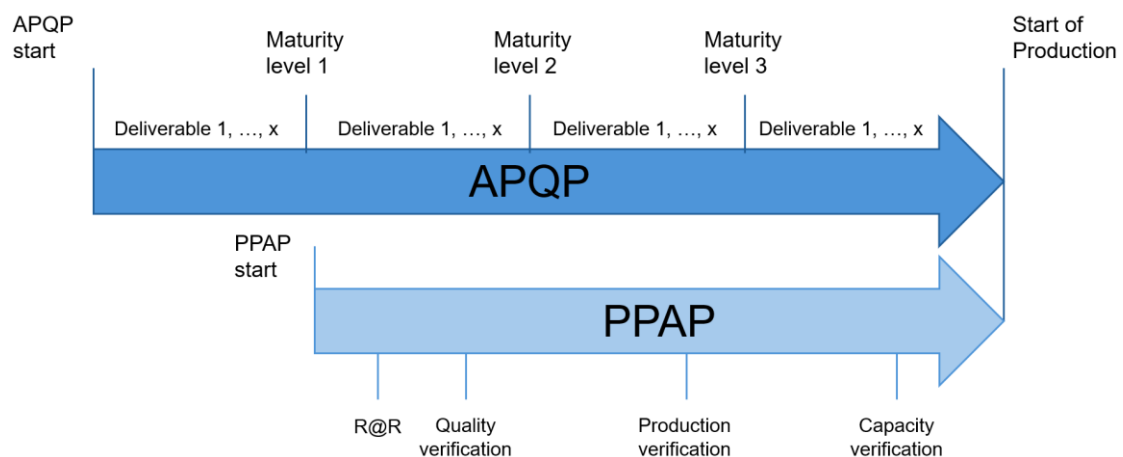


Figure 7 – General Illustration of APQP and PPAP Correlation

4.2 Part II: Identified Challenges

This section presents the findings gathered from key informants and interviews regarding the current challenges that exist in APQP and PPAP. To provide a coherent structuring, the results are presented by their codes and themes as exemplified in the method chapter.

4.2.1 IT System

The theme of *IT System* encompasses findings that can be connected to the digital applications connected to APQP and PPAP. As defined in Part I, there is one separate application for each process, with the APQP application being an adaptation of an affiliate OEM's, and the PPAP application developed in-house. While the IT System at hand encompasses several applications and functions, these results regard only the APQP and PPAP applications. According to several employees, there are improvements that could be made to these applications. Two SQM employees emphasized that today the APQP application is more of a checklist, because *"You only put in information, but you never get anything out of value except a status update"* (S2). Furthermore, there are some hiccups in the system as explained by an R&D employee and a buyer. The R&D employee stated that in the PPAP application there is a possibility of adding deviations that affect the PPAP progress. However, accidental deviations inserted by suppliers cannot be deleted, *"So we'll have a bit of noise in the system. So, we'll have items that we think we need to follow up on because they're rejected, but we can ignore them because they should be deleted."* (R1). The buyer highlighted the importance of ensuring accurate data across the applications, such as supplier identification codes. In one case, the supplier identification code was not aligned with the contractual identification, leading

to difficulties with payment. In line with these hiccups, one SQM employee highlighted the importance of eliminating the human factor through focusing on IT system development.

In addition to these specific inputs, three reoccurring subthemes were identified throughout the interviews. Employees who use the applications for both APQP and PPAP expressed the need for back-end connectivity, allowing data to be transferred between the applications automatically. Employees who do not use the applications highlighted that the company is currently undergoing a digital transition, leading to uncertainties in their future involvement in APQP and PPAP. Also, several employees identified the general need for automation to decrease the time spent on non-value adding tasks.

4.2.1.1 A Contemporary Digital Transition

As highlighted by a procurement employee, the digital system of APQP is not entirely in place for all regions. Currently, employees in Europe generally use the APQP application while employees in Asia use excel, as validated by SQM engineers in both regions. As highlighted by one procurement employee:

“... right now we don't have a system. So it's hard to keep track of all of that and to have the complete, because we should have a system where you could see, you click on the part number, you have the drawings available, and then you click on the same part number and you have the price available and the price history, and then you click on that part number and you see all the quality, history about it, and then you can link it to the tooling, so you could see the team, when was it produced, when was it purchased, what is the life cycle. That should be all in one document, in one big system where you can have access to that” (P1).

Several employees mentioned that the plan is to set up the system for all regions, and that this is under development. According to another procurement employee, there are uncertainties in how this new system will work, and what role procurement employees will play. In moving towards using the APQP application, one employee in Asia expressed: *“Then SQM can just you know, just check all the deliverables by real time in the system. So that's very good. But now currently we are still using the offline excel sheet to track on all the APQP deliverables” (S3).* The in-house built PPAP application is utilized by all regions of the OEM and has recently been introduced, leading to differences in how employees work with it, as mentioned by both procurement employees.

4.2.1.2 Need for Back-end Connectivity

In the transition towards being more digitally driven, several employees have expressed the need for making the applications more integrated. According to an SQM employee, the systems today are isolated, which leads to an abundance of input. As expressed by the employee: *“Reaching PSW requires handling outside of the APQP system. So, PSW is today an application outside of APQP in which you need to add documents which are already in APQP” (S1).* Additionally, another SQM employee added that having back-end connectivity would give better proof whether deliverables have been performed or not. In the current state, deliverables may be done and uploaded in the APQP application, but not in the corresponding location in the PPAP application. According to several SQM employees, the main flow of information should be from the APQP application to the PPAP application. One suggested approach for this was that whenever a deliverable is marked as finished in the APQP application, the corresponding PPAP element should be marked finished

as well. From an IT perspective, this connection is feasible: *“It is pretty much possible. We haven't received any specific requirement for that. That's why so far they are alone. From the IT perspective, there are already APIs built to enable the connection.”* (D1).

4.2.1.3 Automation to Decrease Manual Interference

As a compliment to ensuring back-end connectivity, employees discussed the need for automation as a remedy against the burden of administrative work. The solution architect working with developing the applications of APQP and PPAP highlighted that to complement the connectivity, further automation is needed:

“...the analysis or the object point should be very clear. And integration, okay, I'll bring it to PPAP, but what do you want me to do after bringing that information to PPAP? Is it just to display, or should it have any instructions? If it is below a particular level, should it trigger a mail? If mail is triggered, what should happen? Someone should respond? Okay, if there is no response, what should happen? So, those are the things we need to know” (D1).

In line with this reasoning, the architect highlighted the importance of having a seamless and automatic system, where SQM employees ideally only need to validate the performance of suppliers. Furthermore, both R&D and procurement employees emphasized the importance of automation. One R&D employee pinpointed the importance of automatic communication or triggers, in line with the reasoning of the solution architect. Ensuring visibility of updates would aid employees in knowing what has been done and what action needs to be taken, whether it regards chasing suppliers or uploading documents. Further, the employee mentioned the problem of not having an automated system: *“If it is a system and it's decoupled from your emails, you can forget. Simple human nature”* (R1). This view is also expressed by an SQM employee, who emphasized that there should be triggers connected to the input of a user since the tools are cross-functional.

4.2.2 Cross-functionality

Both APQP and PPAP are cross-functional processes, as highlighted by several employees. According to one SQM employee, the way of internally collaborating with employees and conducting component development depends on the region, the component and the employee. Generally, employees are expected to have “APQP meetings” at regular intervals, where deliverable progress is discussed with suppliers, and issues can be resolved. These meetings are SQM driven, and the extent to which other employees are involved varies. According to SQM employees, logistics employees are only involved for critical issues, leading to logistics-related issues of smaller scale resolved outside of meetings. Furthermore, R&D employees should preferably be involved as they have a central part, but do not always participate. This can lead to additional work when SQM employees need to follow up with R&D employees afterwards, as explained by an SQM employee. Regarding the involvement of buyers, one employee stated *“I think we are not involved enough in a way that we cannot prioritize all the meetings. I think at the APQP meeting slot, I am double or triple booked on a weekly basis.”* (P1). While there are routines for communicating whether employees need to be involved in the meeting or not, one SQM employee expressed the need for better structuring these meetings.

While the APQP meetings as well as other reoccurring meetings are used to ensure progress and issue resolving, employees expressed further improvements in working cross-functionally. As said by one SQM employee, people need to work less in silos and more cross-functionally. Furthermore, another SQM employee highlighted that

employees do not always know what items they should follow up on, emphasizing that there are uncertainties in task ownership. These issues highlight two key sub-themes - variations in task ownership and the need for improving internal collaboration.

4.2.2.1 Variations in Task Ownership

As expressed by several employees, the ownership of tasks related to both APQP and PPAP varies in practice, despite the internal documentation stating the responsibilities per function. For instance, one SQM employee highlighted that a logistics-related deliverable was assigned to them even though a logistics employee performs it, as validated by a logistics employee. Further, both SQM and R&D employees highlighted production-related deliverables that are assigned to R&D in theory but performed by SQM in practice. Also, one logistics employee expressed several similar deliverables that were assigned to them but performed by SQM employees. As a result, employees are not always sure what their tasks are, leading SQM employees to bear the responsibility of leading other functions' work. As expressed by one R&D employee, their way of working was reactive due to waiting for guidance from SQM. On the contrary, one logistics employee highlighted that some R&D employees are very ambitious, which is both good and bad. According to the employee, some R&D employees take ownership of a broad range of tasks due to a strong will to create a good product. This is problematic as it may lead to discrepancies: *"They (R&D) have taken documents from 2014 and sent them to the suppliers. They are not valid at all, but they think that it is a good start. It is a nice ambition, but they do not have to do that"* (L2).

In addition to the broader variations in task ownership, there are also variations in task ownership related to digital applications. When information is not put into the applications, the next function must do the work, as expressed by a logistics employee. The employee discussed an example of where the part-weight was not added by R&D, leading to the logistic employee having to do extra work. Although this information is not directly input in the APQP or PPAP application, it is used by them. Further, employees discussed that SQM employees are mostly responsible for adding information to digital applications. One procurement employee expressed that SQM asks for information from procurement and adds it to the application. According to them, this is a challenge because buyers follow the same milestones and timeline as SQM.

4.2.2.2 Improvement in Internal Collaboration

In line with the statement of the SQM manager, there is a need to improve the internal collaboration. As highlighted by a solution architect that works closely with SQM, there is a gap between SQM and R&D concerning design reworkings: *"We can start with 1 and we are ending up at 10 (designs). And what happened? I thought we were at 3. No, no, we are at 10 now. Maybe 15 before we end this year as well. So it shouldn't be like that"* (D1). When these design changes are not communicated internally, it requires extra resources to realign APQP and PPAP efforts. Further, one logistics employee expressed the need for increased collaboration with SQM to increase mutual understanding: *"Why would it not work to put this (component) in a box? Because then it will be scuffed. Yes, now that I can see it in real life I understand it"* (L2). Today, logistics only communicates with SQM when something shows up, such as resolving issues or clarifying APQP deliverables. As expressed by both logistics' employees and SQM employees, the main reason for this is that the OEM has a slim organization, leading to prioritization.

4.2.3 Involvement

In connection with the two themes of *IT System* and *Cross-functionality*, the theme of *Involvement* concerns the degree to which employees are involved in processes, meetings and interactions. Several employees have mentioned that their involvement in APQP and PPAP are limited at times, and that SQM employees are involved to the highest extent. As explained by one SQM employee, the degree of involvement is not always obvious for the different functions, more specifically logistics and procurement. Although the general attitude is that everyone wants to help, this uncertainty leads to lacking participation in meetings: *“At first, they may participate in a start-up phase. But then they realize that... Oh, I only have one item, I’ll manage it offline and then I can do something else”* (S2). When discussing PPAP, one buyer expressed that their involvement is quite limited outside of formalities: *“If you ask me the buyer roles here, it’s really focused on the contracts... But it’s not really with the process, supplier, production or how they’re doing this. Of course, I think it’s, I miss it this.”* (P2). Furthermore, as expressed by both procurement and R&D employees, system access is not in place for all functions. While this is partly due to regional differences in working with APQP and PPAP, some system access goes through SQM: *“We don’t use the system directly. So if I need to use anything by the system, I’m talking with SQM about the component and then they verify how we do that. So we’re not going directly to APQP system to use”* (P2). As added by another buyer, there are perceived benefits in being involved in the system. In discussing system involvement: *“I think it would be more, not one person driving it, it’s one person driving it, but then asking you to upload information or give your inputs”* (P1). Based on these findings, the two subthemes of system involvement and increased interaction have been denoted, which are further presented below.

4.2.3.1 Need for System Involvement

As SQM are the process owners, the extent to which other functions use the digital applications is dependent on the usage patterns of the corresponding SQM employee. However, a general expression of employees was that their involvement in the system is limited. As said by a logistics manager: *“The APQP application we are not looking into at all I would say”* (L2). One buyer highlighted that they have access to the PPAP application, however they rarely use it. As further expressed by an SQM employee, buyers are often stressed for information as they have no central way of communicating, emphasizing the need for system involvement. Additionally, one R&D employee discussed that using excel as today is not ideal, and being involved in the digital system would be beneficial for ensuring transparency and collectively keeping track of progress.

4.2.3.2 Increased Interaction

Several logistics and procurement employees expressed the need for increased interaction, mainly with suppliers. One buyer highlighted the importance of seeing product samples and process lines instead of presentations, videos and photos: *“Because actually, of course, as you see, as a buyer here, we are not traveling a lot. So, most of the guys here, we just see contracts or presentations, but you’re not going in the suppliers to see how it’s working in the process. So, this is the thing, it’s missing a lot here”* (P2). Also, the buyer added that for any kind of PPAP approval, buyers should ideally be together with SQM to make it. In line with this, another buyer claimed that the best setup for auditing at the manufacturing plant is to bring R&D, SQM, buyers and cost engineers. However, both employees underlined that today

this is not always possible due to time constraints, prioritization and costs. A remedy for this, as explained by one buyer, would be to have more interactions with processes and suppliers overall. If buyers were more involved in seeing the processes, they could find gaps and improvements that could lead to cost reductions. Further, a logistics manager added that visiting the manufacturing plants and talking to employees would be beneficial: *“... it would have been an investment that would pay off, instead of sitting in front of a screen and relying on mail. You can solve a lot of things remotely, but some things are fantastic to see in real life”* (L2). The manager further emphasized that being on-site to talk with employees and suppliers can help with mutual understanding, preventing issue resolving down the line.

4.2.4 Knowledge

The theme of *Knowledge* encompasses the level of understanding across functions regarding APQP and PPAP. Several employees mention significant challenges related to the interpretation and usage of deliverables. For instance, R&D employees described the deliverables as sometimes too vaguely defined in the excel documentation. These descriptions typically outline what is generally expected but fail to guide the reader on how to act. This becomes especially problematic in milestone meetings, where the lack of understanding leads to uncertainties in responsibilities. According to one R&D employee, there is no value in strictly checking deliverables if they do not state what to do. In their case, they know what needs to be done regardless, because they have been working with APQP for several years. The employee highlighted that it works in his case, but a new person may struggle to understand how to perform their tasks and instead wait for another employee to push them. As further highlighted by a logistics manager, the overlap between responsibilities requires too much knowledge from employees as they do tasks outside of their domain. In their case, this presents itself when SQM employees one handedly does both SQM and logistics auditing: *“It’s great that you have a basic understanding, but it’s hard to require all colleagues to know it, like running water too”* (L2).

One SQM employee noted that colleagues at other functions do not always know what to follow up on, mainly due to a lack of understanding: *“The process, I think, it’s not published so clear to all the employees, And also, they also didn’t follow with this document. The training is not enough.”* (S4). As expressed by the employee, further training is needed. However, the training format needs to consider that the SQM division is significantly smaller than the R&D division. Hence, the employee suggests that training for R&D should have a supporting management team to assist with this. As expressed by another SQM employee, internal training has been performed for PPAP. However, due to a lack of time prior to the launch of their new project, APQP training was never performed. Further, the employee emphasizes that knowledge regarding APQP is more important than PPAP, as many APQP tasks serve as input to PPAP.

An overall statement of one SQM employee was that currently, there is a big knowledge gap in what APQP and PPAP mean. Some people believe that a finished PPAP product never breaks, which according to the employee is not the case. While PPAP is a quality assurance process that minimizes the risk of failure, the employee states: *“... it does not mean that we have captured all possible errors that can happen. In reality we have maybe captured 99% of the errors, but there is 1% that can slip through. And when that happens, we plug that hole so to speak”* (S2). Further, the SQM employee expressed the belief that this internal lack of knowledge is due to information unavailability, as was also mentioned by another SQM

employee. However, the bottom line of this gap is that: *“If they (employees) had access to information in the beginning, in an early phase, we would not have the problems that exist right now. It is a pretty easy problem to solve”* (S2).

4.2.5 Ways of Working

In line with the previous themes, *Ways of Working* captures challenges related to how APQP and PPAP activities are executed in practice. As highlighted by an SQM engineer and a logistics employee, the fact that the APQP process is adapted from an affiliate OEM leads to several gaps. As mentioned by the logistics employee, the functions of the OEM work a bit different from the affiliate, meaning that their ways of working are not applicable. Further, they highlighted that the timing of the milestones is not applicable. The same ideas were expressed by the SQM employee, who further added that better tailoring towards the company is needed. To exemplify this, the employee emphasized the need to revise the specific requirements put towards suppliers (see PPAP element 17). As a result of this, combined with the fact that the contemporary APQP process is rather new for the company, there is a big difference in how people conduct it. An additional reason for this, according to an SQM employee, is that APQP has a certain flexibility of bypassing routines, meaning that tasks not necessary for PPAP completion can be skipped. While this may aid those that understand the process, it may have a negative effect on those who don't. Due to this inherent flexibility, sometimes employees focus more on PPAP than APQP, as PPAP is the formal requirement. As further explained by the employee, this approach provides the risk of missing critical steps which need to be taken later, requiring both time and cost. The best practice as explained by them is: *“...I would like that APQP is the only tool you work in, cross-functionally, and when you are done you get the end product, PSW”* (S1). In line with this discussion, several SQM employees have emphasized the need for increased efficiency in the ways of working. As expressed by one employee using excel during APQP: *“You know, normally we have a lot of tasks, a lot of deliverables, so we sometimes we will miss (tasks)”* (S3). Thus, the two identified sub-themes of *Ways of Working* are standardization and efficiency, which are further presented below.

4.2.5.1 Need for Standardization

In discussing the improvement potential of APQP, one SQM employee expressed: *“The disadvantage is that the tool is not used in the most optimal way. Partly because we have general guidelines, but there are still highs and lows. Maybe it needs to be specified more in detail”* (S2). Furthermore, the employee emphasized the importance of rigorously doing tasks in both APQP in PPAP. Otherwise, things may look good in documentation, but bad in real life. On the topic of documentation, one logistics employee highlighted the importance of ensuring that relevant data is communicated and centrally documented. As an example, the employee discussed cases where R&D employees have properly done their tasks in practice but have not updated the documentation. When there are gaps in the documentation, the logistics employee highlighted the need for either finding the necessary information themselves or working without the full picture. As expressed by an R&D employee, the current approach to APQP is pursuing daily tasks without formally following deliverables, because many deliverables of APQP are incorporated into their day-to-day work. While the employee states that there are several different approaches of R&D employees, their approach is reactive, as not being contacted by SQM employees can lead to the assumption that all is going well. Another R&D employee problematized the usage of conducting APQP through an excel sheet, stating: *“we're*

going by what we have on the Excel sheet and any new items we might want to raise. So there is a risk of missing, of missing tasks that you need to do for each gate” (R1). While the excel sheets can be used for tracking progress, this isolated documentation leads to a lack of transparency, and difficulties in backtracking.

4.2.5.2 Potential for Increased Efficiency

As expressed by several SQM employees, there is a need to make the processes more efficient, mainly concerning APQP. According to one employee: “APQP is definitely a very, very good tool and I think as I mentioned. We need to make it more efficient” (S3). According to an SQM employee, the biggest pain point of APQP is that today there are many deliverables, leading to much administrative work. Consequently, this makes APQP too heavy to apply at times. As further added by another SQM employee “... I would think that it (APQP) is a bit too comprehensive. Some things could be slimmed down” (S2). As mentioned by the employees, the main aspect of making APQP more efficient lies in cutting and streamlining the number of tasks/deliverables that are performed.

4.2.5.2.1 Deliverable Cutting

From asking employees who pursue deliverables connected to APQP, it was concluded that the total number of deliverables could be decreased by 8%, up to 15% if considering less confident cuts. Some of these cuts, as explained by an R&D employee, are due to the iterative nature of certain deliverables, which are progressively refined throughout the industrialization process. In one example, the employee noted that a deliverable could be removed because, in practice, it is not completed at the point in time specified by the documentation, but rather at a later stage. Further, one logistics employee stated that some deliverables are simply not performed, and therefore should not be used, emphasizing the need to make the deliverables fit reality. This was further expressed by an SQM employee who stated possibly redundant deliverables that are not performed, often due to their timing or feasibility. Further, several employees expressed the potential of cutting deliverables that are not directly related to APQP but encompasses checking surrounding processes such as quality issue resolving. An example of this, as explained by an SQM employee, are two deliverables connected to making sure that digital ordering is properly set up between the supplier and company.

4.2.6 Project Management

Project management captures the key findings in the areas of project planning, coordination and how follow-up of activities are carried out across the departments. From interviewees the challenges in practice concerned planning consistency, escalation paths and the balance of time, quality, and cost. The following chapter has been divided into three sections which are presented below.

4.2.6.1 Incomplete gates

Although the APQP structure is meant to support a disciplined, gated project approach, employees note that sticking strictly to the gate structure doesn't always happen in practice. Logistic employees described some challenges in keeping the project structure and rigor intact, where plans are sometimes adapted more flexibly, which can compromise the intended phase. One suggests that time constraints associated with a fast-paced market introduction may affect the completion of phases: “They never really complete the development phase. They go straight into production start.” (L1). The employee links this with challenges such as moving forward before all project phases are finalized and notes: “Why move on from one gate if the prior ones haven't been completed?” (L1). Furthermore, the employee

specifically identifies the verification process as a critical point of incompleteness. From an SQM employee it is also said: *“ You can fill in a good APQP. But if you haven’t done the technical work... then it looks good on paper, but it’s bad in reality”* (S2).

4.2.6.2 Compliance with project tasks

Another logistics employee also expressed the importance of verifying processes and working proactively to address incomplete tasks rather than postponing them. The employee suggests that repetitive postponing of tasks connects to the general issue of lack of discipline, to which they add *“It’s really bad to do very little in the beginning and then a lot at the end. But that’s exactly what we do. And we have a hard time respecting deadlines”* (L2). Further the employee highlights this to be a critical issue in the organization as it does not only affect cost and resources but moreover affects downstream processes. According to another the logistics interview (L1), there is a tendency among operational staff to prioritize practical execution over formal procedures such as KPIs and extensive work instructions, which are sometimes perceived as obstacles to efficient day-to-day tasks. Further the employee describes the feeling as: *“The problem sometimes is that we’re building a highway, we’re laying the ground, but when you look underneath, you can see through to the other side. Because the foundation hasn’t been put in place”* (L1). From another employee the similar is expressed: *“But it’s also the case that everything has to be slimmed down and become a bit controlled. It gets quite... you could say it gets a bit intense. It’s like we’re building the bridge while driving on it, in a way.”* (L2).

4.2.6.3 Support in decision-making

Several functions express a need for additional support in decision-making beyond the current cross functional team. Although the OEM has a designated launch management function, employees noted that this team operates at an industrial level, with focus on the overall vehicle industrialization process rather than on the coordination of individual components. Due to this, it becomes a matter of escalating component level issues to get support from the launch team. It is also suggested that the geographical positioning of the launch organization may influence the team's perspective, potentially leading to a narrower focus that does not fully reflect a neutral or cross-functional viewpoint. Further, this current setup suggests challenges in balancing the time needed at componential level vs aligning the vehicle industrialization. As a logistic employee expressed:

“We don’t need to sit in the factory, but we should observe and coordinate things—logistics, SQM, and the actual manufacturing side that builds the car. A place where we can also come together with a common point of contact to discuss issues that might need resolution somewhere. Where on the scale should we land? Something that works really well for me might be really bad for SQM—or the other way around. Someone needs to take a step back and consider: what’s a reasonable balance for everyone? That’s a valuable decision-making function” (L2).

Thus, while referring to the vehicle level the employee suggests that the cross functional team would benefit from organizational support closer to operational component level, in less critical decisions rather than having to escalate them.

4.2.7 Supplier

The supplier section discusses the relation between the OEM and its suppliers, seen from the perspective of the OEM. From the interviews two main concerns were identified: information sharing and experience. Information sharing concerns the interactions mainly between suppliers of tier 1 and the OEM, that encompass all used communication channels from digital systems to direct contact. Experience focuses

on whether the suppliers have any previous experience working with the OEM, and what impact this experience has on the success of that supplier relationship.

4.2.7.1 Information Sharing

A general issue expressed by employees concerns the way suppliers share information, which tends to fall into two distinct behaviors: either the supplier is unaware of their limited information sharing, or they are deliberately reluctant to share information. In the prior case several employees notes that suppliers do not understand what information is needed for the process, which requires the OEM to guide the supplier on what information to share. As one notes: *“We need to push them and remind them..., most of the changes that are supplier-driven, we don't have transparency that they are supplier-driven right now.”* (R1). An SQM interview pinpoint the same issue by highlighting the importance of early-stage information sharing to avoid risks: *“if we identify risks at the beginning we can discuss with the cross-functional team and also the supplier to see if there is any backup plan or corrective plan”* (S4). In response employees emphasize the importance of clear communication. An R&D employee notes the importance of clarification in making suppliers understand deliverables. Meanwhile, a logistic employee emphasis clear communication in response to the large quantities of information suppliers deals with:

“But if you're a supplier and dealing with tight prices, you might get a 500-page purchasing contract full of fine print. From different departments, different sections, different conditions. Even if you read it, I can guarantee that by the time you reach page 470, you're pretty exhausted. So you don't really understand what you're reading anyway—roughly speaking.” (L2).

It is further elaborated by a buyer who claims that it is the OEM's responsibility to communicate clearly and not the supplier, as they are the one defining the requirements.

In cases where suppliers are withholding information, this is often due to concerns of confidentiality. The issue tends to increase when the supplier has ownership of the product or process, as this can involve not only trade secrets but also legal restrictions that prevent certain information from being shared outside the country. An example of this is noted for supplier owned parts which requires the OEM to perform DFMEA audits on-site as the supplier otherwise won't share the information. An R&D employee elaborated on the issue as:

“...the FMEA they showed us was very basic. They wanted to get through with doing minimum work to just quickly satisfy us as a customer. We worked with them a lot on their FMEA to make sure that what you see on screen and what you read is understandable for anyone that comes into the room. It shouldn't only be me that's seen it several times that understand what it means. It should be a new person as well. It also means that their FMEA of course needs to be detailed for the component, but it also needs to be specific” (R1).

Therefore, the employee highlighted a lack of clarity and specificity which not only affect comprehensiveness among those present during the on-site audit but also external stakeholders at the OEM who need the information. In response to this, the employee emphasized the importance of thoroughly reviewing supplier documents to reduce overall risks from informational gaps. However, such passive information sharing might reflect a general approach as the same R&D employee said: *“We work*

with the (battery) cell as a black box, which means that we are told limited information about it...It's the industry standard" (R1).

4.2.7.2 Experience

When considering suppliers, it is repeatedly noted that experience is key for the success of a supplier. According to a procurement employee, part of the experience relates to practicalities where experienced suppliers are more successful in the execution of process such as casting or molding. Further the employee said that suppliers who carry previous experience working with the OEM has a better initial understanding of the OEM's unique requirements as well as processes and systems, making the success less reliant on the OEM to communicate the expectations. In this respect it is repeatedly noted by employees that experience not only encompass previous work with the OEM but further applies to experience with the affiliate OEM from which they share similarities in processes with. As one buyer tells: *"So all suppliers have to follow the company's official guideline for quality. And then there is a list of requirements... if they have worked with the affiliate, they know this list of criteria."* (P1). As a result, these suppliers are more associated with accurate monitoring and strict quality checks aligned with the OEM requirements which according to the buyer may be the main reason that one supplier succeeds better than another. In contrast it is also noticed that the initial phase of dealing with inexperienced suppliers is seen as time consuming. As a buyer says *"...you need to take a lot of time to explain it, to teach them, and also if they make some claims, then you answer again. So a lot of rounds of discussions"* (P2).

5. Analysis

In this section, the empirical findings are analyzed using the theoretical framework. Primarily, the CMMI framework is used to structure and organize the analysis of key gaps. However, rather than ranking the performance of each process area, CMMI is applied to characterize maturity behaviors and aid in identifying potential actions.

The application of APQP and PPAP in supplier collaboration functions as a shift from reactive inspection to proactive quality assurance. This transition enables earlier risk identification and defect prevention, as highlighted by Attia (2024). Moreover, the OEM's approach of investing in supplier tooling as a performance incentive reflects the use of strategic investment to drive supplier quality improvements, consistent with findings by Lee & Li (2018). Finally, the inherently collaborative nature of APQP and PPAP supports several practices recognized in literature, such as early supplier involvement in product development (Noshad & Awasthi, 2015).

The process areas of *Project Planning (PP)*, *Integrated Project Management (IPM)*, *Organizational Process Definition (OPD)* and *Organizational Training (OT)* fall under two categories - project management (PP and IPM) and process management (OPD and OT). When thematically analyzing the empirical findings, it was concluded that these four areas would allow for nuanced analysis of the different aspects of APQP and PPAP. While IPM and OPD were chosen due to their heavy correlation to cross-functionality and process standardization, PP and OT were chosen to capture the overarching management of the processes in terms of planning, execution and knowledge management. Based on the empirical results, mapping was performed to link the themes of challenges identified in the empirical to the process areas, as seen in *Table 9*.

Table 9 – Mapping of Empirical Themes and Process Areas

Theme	Code(s)	Process Area(s)
IT System	Back-End Connectivity, Digital Transition, Automation	OPD, IPM
Cross functionality	Task Ownership, Internal collaboration	PP, IPM
Involvement	System Access, Supplier Interaction	IPM
Knowledge	Knowledge	OT
Ways of Working	Standardization, Efficiency	OPD
Project Management	Project Management	PP
Supplier	Information Sharing, Experience	OT, IPM

5.1 Project Planning

In CMMI, Project Planning (PP) means creating clear and realistic plans for how a project will be carried out. This includes defining activities, setting deadlines, allocating resources, identifying potential risks early, and making sure that activities follow a logical sequence.

The process area of project planning captures the findings from the theme of project management. The following section analyzes how deviation from APQP structure occurs at the OEM, what drives them, and how they relate to trade-offs between time, cost, and quality as conceptualized in the triple constraint theory (Adler, 2018).

5.1.1 Current state of PP

The OEM has implemented a formal planning structure through its APQP framework, intended to guide development in a systematic, phased manner. However, employees reveal that the model may be bypassed or applied inconsistently,

especially under time pressure. Phases are sometimes advanced before the prior ones are complete, resulting in incomplete deliverables and unresolved issues being pushed forward. Moreover, misalignment in cross functional decisions is seen to affect short-term prioritization which further indicates a need for support.

These deviations increase the risk of downstream rework, quality issues, and higher project costs, demonstrating the practical tension of the Triple Constraint (Pollack et al., 2018). While key planning elements are in place, the OEM would benefit from reinforcing consistency and oversight of project planning. This would support progress toward CMMI level two – managed, where processes are actively controlled, and lay a foundation for eventually reaching level three – defined, where planning becomes an integrated and institutionalized part of the development culture.

5.1.1.1 Project Management

As the interviewees indicated, execution sometimes deviates from the intended structure, with activities occasionally progressing in a nonlinear manner and certain tasks remaining incomplete. According to the Triple Constraint, time, cost, and quality are interdependent, meaning that prioritizing one inevitably results in trade-offs with the others (Pollack et al., 2018). In this case, the emphasis on rapid progress may come at the expense of both lower quality and downstream cost to address the quality issues.

From the quality perspective, a tradeoff is seen when phases progress prematurely, leaving certain tasks incomplete. Based on a logistics employees' observation about new gates opening before prior ones are closed, the occurrence of phase overlapping is seen, where downstream activities are initiated before upstream ones are finalized. Orm & Jeunet (2018) emphasize that, while this approach may appear to accelerate project progress, it increases the likelihood of rework and coordination failures due to unstable or incomplete inputs. Further the incomplete progression is noted when an employee suggests that documentation is filled in to look good on paper rather than focusing on technical execution. Firstly, this approach may cause a false sense of readiness if incomplete tasks are ticked off, which contradict FTR who promotes preventative quality built in the execution (Kumar Singh et al., 2023). Secondly, documenting tasks before thorough execution reflects an incorrect approach to validation which disrupts the principle of the PDCA loop by undermining the "Check" stage.

Following the compromised quality, risks can be seen to follow downstream in the form of reassessing incomplete tasks. From a cost perspective it was noted by several employees that issues emerging downstream tend to be significantly more expensive to resolve. These reflections reveal a recurring pattern in which early-phase shortcuts lead to resource-intensive problem-solving later in the project lifecycle. As the timeline advances and unresolved quality issues accumulate, the complexity and cost of addressing them increase substantially. This risk is illustrated by Liao et al.'s (2020) project crashing curve which shows that accelerating project activities beyond an optimal point lead to exponentially rising costs. Therefore, by assuring upfront quality and ensuring disciplined phase completion, the OEM will be able to avoid crossing this threshold and reduce risks related to high costs of correction.

While the trade-off dilemma is clearly visible at the OEM, it may also be understood as an unavoidable occurrence rather than simply a deviation from intended procedures. Referring to Van Wyngaard et al. (2012) expression, "*Good, fast, or cheap? Pick two*", the trade-off between time, cost, and quality can be seen as an

inevitable challenge that companies must manage. In this context, compromising on certain process steps may serve as a necessary response to meet delivery goals while still aiming to uphold quality elsewhere. This dilemma is reflected in the statement about the APQP process at the project level: *“They never really complete the development phase. They go straight into production start”* (L1). The comment suggests that time-crashing is also influenced by top-down decisions, where the pressure to meet program timelines reflects how progression is made. As a result, time pressure influences planning and execution, where the early phases may receive less focus, and much of the work is deferred to later stages.

The tendency to prioritize speed over structure also seems connected to limited planning support. The interviewees suggested that coordination between functions could be strengthened. As one logistics employee expressed: *“Someone needs to take a step back and consider: what’s a reasonable balance for everyone?”* (L1). While a launch management function does exist, it operates at a higher level and is relatively distant from day-to-day operational challenges. Because escalation is required to receive their support, it can be difficult to receive them in a timely manner, when priorities clash or issues arise. This may discourage teams from seeking guidance and further suggests a need for increasing organizational support, which plays a critical role in balancing the triple constraints. According to Watanabe et al. (2024), organizational support is not just an administrative function but a direct moderator of how effectively teams can manage project complexity and tradeoffs. Watanabe et al. (2024) claim that when such support is inaccessible or overly formal it may lose its moderating power which at the OEM is reflected in reactive decision-making and short-term prioritizing. This makes it harder to protect process quality or ensure that earlier phases are truly complete before moving on. Thus, Watanabe et al. (2024) argue for embedding organizational support at the operational environment as it will not only facilitate cross functional alignment but also serves as a key in timely intervention.

In summary, time pressure, limited planning support, and incomplete phase execution illustrates the Triple Constraint dilemma the OEM is facing within the development process. While some trade-offs may be necessary, the repeated deferral of technical work and fragmented coordination suggest systemic weaknesses rather than calculated decisions. These findings point to the critical role of project planning and embedding organizational support to balance functional priorities, reinforce preventive quality measures, and ensure disciplined project progression. Strengthening this support closer to operations may serve not only as a buffer against reactive decision-making but as a structural enabler of long-term project success.

5.2 Integrated Project Management

According to CMMI, the ideal state of IPM encompasses clear definition of roles and responsibilities, structured collaboration across functions, consistent engagement of relevant stakeholders, and effective integration of supplier activities (Chrissis et al., 2011). Strong IPM practices ensure that all parties, internal and external, are aligned throughout the process of component industrialization, minimizing misunderstandings, delays, and quality risks. For APQP and PPAP, this implies that there are routines for collaboration, meetings and ownership regardless of whether the component is complex or basic. Ensuring structured project management may help with incorporating lessons learned, as an existing process can act as a benchmark, in line with the “Check” and “Act” stages of PDCA, as explained by Pietrzak & Paliszkiwicz (2015).

The process area of IPM concerns cross-functional integration and coordination across the organization and suppliers, as defined by Chrissis et al. (2011). Due to the broad stakeholder focus, the process area is directly related to the empirical themes of cross-functionality, involvement and supplier. Further, as the digital applications for both APQP and PPAP are collaborative, the theme of IT system is related to IPM.

5.2.1 Current State of IPM

As expressed by several employees, the collaborative nature between stakeholders faces high variability. Although the internal documentation provides an outline of responsibilities and structures of meetings, it varies in practice. While some of these variations are due to justifiable factors such as complicated components or suppliers, there is a need to clarify these processes. Through clarification, most components could be industrialized via APQP and PPAP using routine processes, which is what capability levels two and three encompass (Chrissis et al., 2011). Further, the digital applications for both APQP and PPAP is not entirely in place, with some employees relying on excel for keeping track of progress. In the transition towards being more digitally driven, several employees highlighted the need for understanding how to use these applications, and what responsibilities they bear. Currently, there are uncertainties in how information should be put into the system, and how the functions of the applications can best be utilized. While there is an overarching need for defining the role of the APQP and PPAP applications, SQM employees who currently utilize both emphasized the need for back-end connectivity. Due to the APQP and PPAP applications being disconnected, tasks need to be manually done in both, sometimes leading to discrepancies and traceability difficulties.

5.2.1.1 Involvement

As described by Fonseca (2015), there are seven principles of ISO 9001:2015 used to navigate complex environments and foster continuous improvement. Two of these, *Engagement of people* and *Relationship management*, emphasize the importance of involving individuals and managing interactions with relevant stakeholders to sustain quality performance. From the interviews, it has been apparent that SQM employees are largely driving APQP and PPAP together with suppliers, with the involvement of logistics and procurement being limited at times. While supplier verification formally lies with SQM, who must also ensure cross-functional contribution, the strong interdependencies with other functions highlight a need to review the current involvement structure. This aligns both with ISO 9001:2015's principles of Engagement of people and Relationship management, which call for active involvement of all relevant stakeholders in key processes, and with CMMI's IPM goals, which mandate clearly defined, structured collaboration across functions to manage interdependencies proactively (Chrissis et al., 2011; Fonseca, 2015). Employees offered different perspectives on how and why involvement varies. While an SQM employee expressed that buyers do not always participate in meetings due to not seeing the value of their involvement, a buyer expressed that they cannot always participate in meetings due to double bookings. Further, with the logistics function being relatively slim, their meeting involvement mainly considers critical issues as they cannot prioritize all questions. Also, both procurement and logistics employees expressed a limited system involvement. While this can partly be accustomed to the ongoing digital transition, these findings suggest that the role of procurement and logistics in terms of system involvement needs to be considered. As expressed by an SQM employee, buyers are often stressed by suppliers and colleagues for information due to their information not being readily available. In line

with this, the employee suggested that the effort of buyers could be decreased if their information was made available in the IT system.

Beyond defining the roles of procurement and logistics, employees of both functions said they wanted more hands-on engagement, seeing processes in action and having them explained, alongside more direct interaction with suppliers. Employees from both functions emphasized that a higher interaction would increase understanding, thus increasing the quality of work. While a buyer expressed that seeing actual processes and products would help in negotiation, a logistics employee expressed that discussing with supplier's face to face greatly helps in mutual understanding, especially on topics hard to communicate via mail. Visiting supplier sites and understanding their processes is emphasized by Noshad & Awasthi (2015) as important for improving buyer-supplier relationships. Although site visits are seen as valuable, employees acknowledge they are often deprioritized due to time and cost constraints. This prioritization could be related to the Triple Constraint, as expressed by Pollack et al. (2018). In line with the framework, it could be argued that employees see value in improving the quality of work over cutting costs, suggesting a rebalancing of the three aspects. While employees expressed the desire for clearer involvement, they also emphasized the need for increased cross-functional collaboration.

5.2.1.2 Cross-functionality

Currently, there are variations in task ownership among R&D, logistics and procurement employees. While the internal documentation clearly states the deliverable ownership, practical implications lead to differing execution. With SQM employees having internal control over APQP and PPAP documentation, and being the closest supplier contact, they perform and verify several deliverables that are assigned to other functions. According to Stamatis (2018), a success factor for APQP is clearly defining roles and responsibilities, which highlights the need for clarifying task ownership. While the current approach appears functionally acceptable, two R&D employees expressed that they are more reactive than proactive, and one logistics employee expressed that employees cannot be experts in all fields. Consequently, when employees execute tasks outside their core responsibility, the quality may not match that of the designated function. This reflects an ad hoc approach typical of CMMI capability level one, where processes are performed but not institutionalized (Chrissis et al., 2011). Without clear institutional ownership, task execution relies on individual initiative, increasing variability and reducing the likelihood of consistent quality outcomes.

As a complement to redefining task ownership, employees emphasized the need for better alignment between functions. For instance, SQM employees mentioned a misalignment with R&D where design changes are not communicated clearly and timely, leading to extra workload. This mirrors challenges described by Oliva & Watson (2011), where deficiencies in cross-functional coordination in supply chain planning processes resulted in conflicting departmental priorities, and recurring inefficiencies. Addressing foundational product changes in a timely manner is vital for APQP and PPAP, as late changes may require redoing earlier development tasks. Further, one R&D employee said that when working with excel-driven employees, there is a lack of transparency both in backtracking progression and in understanding where the information goes. As also expressed by a logistics employee, there is a

desire to increase communication frequency with SQM. While these findings point to a need for slightly aligning internal collaboration, they suggest a certain misalignment with ISO/TS (IATF) 16949, which emphasizes both traceability and clear communication channels (AIAG, 2003).

5.2.1.3 Supplier Integration

While APQP and PPAP are designed to facilitate structured collaboration between the OEM and its suppliers, the findings reveal variation in how this collaboration is realized. The success of such coordination depends not only on the complexity of the product but also on the supplier's familiarity with these frameworks. As Flynn & Flynn (2005) note, collaboration is most effective when formalized and consistently applied, a condition not uniformly present across supplier relationships. Interviewees observed that experienced suppliers generally understand and follow APQP and PPAP requirements, whereas newer or less familiar suppliers often need repeated clarification. This suggests a gap in how expectations are communicated and operationalized. Some suppliers lack familiarity with the OEM's quality processes, while others struggle to interpret the underlying intent of these frameworks or underestimate their importance. As one SQM employee explained, there is sometimes a perception that APQP is simply a documentation exercise: *"So we need to make sure suppliers, and the company are on the same page. To understand about the APQP tool to let them know, OK, that's not only paperwork"* (S3). This reflects a deeper challenge, not just enforcing process compliance but cultivating shared understanding of APQP and PPAP as active risk management and coordination processes. Bai & Sarkis (2016) emphasize the importance of intangible, knowledge-based collaboration, such as mutual understanding, communication, and technical alignment, as essential for effective supplier engagement. In the absence of institutionalized routines to support this, reliance on informal and reactive clarification persists. While experienced suppliers may navigate these expectations through tacit knowledge, others require more structured and consistent engagement. Without such measures, the planning potential of APQP and PPAP is diminished.

Achieving shared understanding relies not only on clarifying expectations but also on enabling timely and transparent information exchange, a key element of collaborative practices as emphasized by Attia (2024). However, R&D employees noted that this can be difficult to achieve in practice, particularly when working with supplier-owned designs. In such cases, suppliers may hesitate to share detailed information, especially regarding risk-related documentation, which reflects challenges also identified by Lee & Li (2018). While this is partly due to trade secrets, it is also that the laws of some countries regulate the extent to which information can be shared. As expressed by one R&D employee, this may prove problematic when suppliers are not allowed to extensively disclose material contents, leading to difficulties in traceability. Concerning trade secrets, suppliers sometimes only present FMEAs on-site, leading to difficulties in sharing the findings with the rest of the organization. While these constraints are understandable from a legal and business perspective, they can contribute to a fragmented understanding within the OEM and reduce the organization's ability to proactively manage risk. This viewpoint is also stated by Attia (2024), who further adds that information sharing should be accompanied by aligning goals, ensuring both risk mitigation and cost reduction.

While these challenges suggest further formalizing supplier integration, they also highlight the need for a structured and clear digital infrastructure. Currently, the use of the APQP and PPAP applications does not fully merge with the ways suppliers understand and conduct their daily operations. Ensuring a compatible and computerized information system with suppliers helps assess performance and progression, as defined by (Chin et al., 2006).

5.2.1.4 The Role of APQP and PPAP Applications

The applications for APQP and PPAP are intended to serve as collaborative processes for tracking progression, ensuring transparency, and supporting cross-functional alignment. As per CMMI capability level three, the usage of such tools should be routine and institutionalized, while remaining flexible enough to address a wide range of variations (Chrissis et al., 2011). However, the empirical findings suggest that the current use of these applications remains ad hoc, with different approaches to documentation, varying levels of involvement, and diverse usage practices across functions. Employees from both R&D and procurement highlighted the benefit of being included in these digital applications, enabling them to follow progression and act proactively. Currently, SQM employees largely serve as facilitators in the APQP application, inputting and extracting information on behalf of other team members.

As several employees expressed, the consistent insertion of information is vital for maintaining oversight of project status, which applies to both internal teams and suppliers. Internally, failure to document progress and performance effectively can result in redundant or corrective work by other functions. Externally, missing documentation may prevent the OEM from accurately assessing the supplier's readiness and progress. Chin et al. (2006) emphasize that traceability, performance monitoring, and coordinated technology use are essential components of SQM. The current documentation practices, however, are fragmented. Information overlap between the APQP and PPAP applications must be manually duplicated, which introduces the risk of inconsistency and hindered traceability.

SQM employees, who routinely use both applications, pointed out the need for improved back-end connectivity. Enabling information entered in the APQP application to transfer automatically to the PPAP application would reduce administrative overhead and enhance transparency both internally and externally. This need aligns with ISO/TS (IATF) 16949, which emphasizes traceability, documentation control, and structured information exchange (AIAG, 2003).

5.3 Organizational Process Definition

According to CMMI, the ideal state of OPD entails the availability and consistent use of organizational process assets that are tailored to project needs. These assets should be clear, accessible, and regularly updated to reflect lessons learned and process improvements. Well-defined and institutionalized processes serve as a common reference point for all functions, enabling shared understanding and predictable execution. For APQP and PPAP, this means that documentation such as checklists, templates, and standard work should be readily available and reflect actual working practices. A structured approach to defining and maintaining these resources can support understanding and continuous improvement. Moreover, the ability to use existing processes as benchmarks allows for more effective incorporation of lessons learned and promotes alignment across projects and regions.

The process area of OPD focuses on the development and maintenance of organizational process assets that guide consistent and effective project execution (Chrissis et al., 2011). This includes the definition of procedures and work instructions that support quality, repeatability, and knowledge transfer across projects. In the context of APQP and PPAP, OPD is directly related to the theme ways of working. Furthermore, as key information is maintained and communicated partly through digital tools, the theme of IT system is also connected.

5.3.1 Current State of OPD

While there are documents on how to conduct both APQP and PPAP, several employees highlighted that there are practical variations. In line with the IPM analysis, there are justifiable reasons for these variations, such as difficult suppliers or complicated components. Also, since APQP and PPAP are used whether industrializing a battery pack or a seat, all deliverables and elements are not applicable, leading to varying requirements on a project basis. However, in the current state, there are indications that the OEM would benefit from further standardizing their ways of working, making documentation reflect practice in line with CMMI capability levels two and three (Chrissis et al., 2011). As expressed by an SQM manager, employees sometimes take shortcuts in APQP because it is seen mainly as a guideline, while PPAP is the formal requirement. While this can partly be attributed to the need for clarifying APQP procedures, it can also be attributed to the need for making APQP more efficient. Currently, APQP is sometimes too heavy to apply, as expressed by several SQM employees. Further, in moving towards a digitally driven organization, there is a need for standardizing the usage of the APQP and PPAP applications, ensuring that a best practice can be formed and maintained.

5.3.1.1 Ways of Working

When discussing the execution of APQP and PPAP, several employees highlighted that there are differences in how people approach them. As APQP is the more flexible process, people sometimes go straight towards PPAP, as expressed by an SQM manager. This approach may lead to missing critical tasks which have to be done later, requiring both time and cost. The notion of structurally following a project to decrease rework can be linked to the FTR principle, which emphasizes higher accountability and rigor in early development (Poppendieck, 2002). Since several tasks performed in APQP reflect PPAP elements, the benefit of approaching APQP prior to PPAP is clear. Also, ensuring an organization-wide approach to APQP and PPAP as per CMMI suggests the usage of a standardized approach (Chrissis et al., 2011). With some employees using excel for APQP and others using the application, it is hard to ensure a standardized approach. Therefore, aligning all employees with the digital applications would help close the gap between the different ways of working. Since several employees utilizing excel expressed a positive attitude towards being more digitally driven, this could be seen as a natural step: *“You know, they (suppliers) just need to fill in the system. Then SQM can just check all the deliverables in real time in the system. So that's very good”* (S3).

As expressed by both SQM and logistics employees, the current APQP process is based on an affiliate OEM's, leading to an approach that does not entirely fit the OEM: *“We are different companies with different conditions and so forth. So, some of the questions are maybe not suitable for us”* (S2). While using an established structure provides a valuable foundation, there is a need to further adjust and refine the process to better reflect the OEM's specific conditions. This is consistent with AIAG's guidelines, which recognize that APQP is not a rigid framework but one that should be adapted to the organization's product, processes, and operational context

to ensure effective quality planning and risk mitigation (AIAG, 2008). As further emphasized by the same employee, it is important to have a good approach for managing deviations and always ensuring gradual improvement, emphasizing the importance of standardization and continuous improvement. This aligns with the principles outlined in ISO/TS (IATF) 16949, which highlight the need for organizations to establish structured processes that both ensure conformity and promote continual refinement of the quality management system (AIAG, 2003).

Due to the different organizational setups between the affiliate and the company, the deliverables in APQP are not executed the same. Generally, it was noted that all deliverables are not always performed, either due to redundancy or an unclear purpose. Further, it was noted that deliverables are not always performed when the documentation states that they should be, indicating different approaches to timing. In line with the higher capability levels of OPD, ensuring documented processes that align with practice is vital, highlighting the importance of tailoring deliverables (Chrissis et al., 2011). For deliverables that represent iterative refinements of the same task, one R&D employee expressed that later stages are sometimes prioritized over prior stages due to formal requirements, compromising its compound effectiveness. This reflects a misalignment between formal documentation checkpoints and the logical flow of development work, suggesting a need to revisit the sequencing and integration of such tasks. In line with this, several employees highlighted the need to make APQP more efficient by reducing the number of deliverables through cutting and combining, as well as adjusting their placement in the project timeline.

From discussing the outlook of decreasing the number of deliverables and restructuring them, it was concluded that approximately 8 –15% of the current deliverables can be cut. However, it is important to note that the attitudes of the different employees varied. While one SQM employee saw several confident cuts that could be made, another SQM employee was not as confident that the number could be reduced. Further, one R&D employee stated that deliverables not directly connected to APQP, such as deliverables surrounding outside processes, could be cut. In contrast, one SQM employee stated that while these deliverables are not vital for APQP itself, they are important for keeping track of sub-process progression. Thus, these findings suggest it is possible to alter the current deliverables. However, for full-scale refinement, more information is needed. While the usage of APQP and PPAP generally could benefit from clearer guidelines and procedures, the move towards using APQP digitally also encompasses ensuring defined processes regarding the digital applications.

5.3.1.2 Usage of APQP and PPAP Applications

As expressed by a logistics employee, *“To understand quality it should be measured”* (L1), emphasizing the importance of properly documenting progress. In discussing the usage of digital applications, several employees expressed the importance of creating and maintaining documentation practices. Due to non-standardized ways of working, employees sometimes do tasks without thoroughly documenting them, leading to uncertainties among cross-functional teams. Further, when suppliers do not upload files such as control plans, or follow proper date formatting, this creates uncertainties in the project. Moving toward higher CMMI capability levels calls for

these documentation routines to become institutionalized, ensuring consistency and traceability across teams and systems (Chrissis et al., 2011).

Establishing clearer expectations for documentation also aligns with the ISO 9001:2015 principle of *Evidence-based decision-making*, which highlights the role of accurate records in maintaining control and supporting continuous improvement (Fonseca, 2015). Defining how deliverables should be recorded in the systems, both internally and by suppliers, could help reduce ambiguity, promote accountability, and strengthen collaboration between functions. In addition to documentation practices, the way the digital system is currently structured also plays a role in creating inefficiencies.

As the APQP and PPAP applications are currently disconnected, this adds further complexity where employees and suppliers sometimes need to upload the same documentation twice, once per application. While this can partly be addressed through ensuring back-end connectivity, not all elements of APQP can currently address PPAP approval. Thus, there is a need for further defining the practical interplay between APQP and PPAP. As emphasized in AIAG's APQP guidelines, digital tools should be structured to reduce duplication and support clear communication between process phases (AIAG, 2008). Clarifying how the systems complement each other in practice would support more efficient workflows and improve overall process alignment.

5.4 Organizational Training

From the CMMI definition of OT, it entails committing to structured training programs with the goal of providing employees with sufficient resources in terms of knowledge and skills so that everyone can successfully and effectively perform their role. At the OEM this includes ensuring that the internal functions of SQM, logistics, procurement, R&D as well as key suppliers, have a clear understanding of APQP and PPAP, including their responsibilities, the timing of their involvement, and how to carry out their tasks in alignment with process expectations.

5.4.1 Current State of OT

Based on the current APQP and PPAP training material, the OEM indicate a general awareness of Organizational Training. However, several employees say that deliverables are unclear and lack guidance on their role and timing, which suggest that training is not yet fully role-specific or task-oriented. Learning tends to rely on informal or non-standardized methods rather than structured onboarding or standardized routines. While this works in smaller teams like SQM, it becomes harder to manage in larger departments with more variation and turnover. Similar patterns are seen among suppliers. Experienced suppliers adapt more easily, while newer suppliers often require repeated clarification. When on-site presence isn't possible, understanding drops, and there are few remote routines in place to fill that gap.

These findings suggest that while efforts toward training are in place, the current approach is still experience-based and dependent on functions. To align more closely with CMMI level two expectations, where training should be planned, repeatable, and tailored to functional roles (Chrissis et al., 2011), there is value in formalizing onboarding routines and enabling more scalable knowledge transfer, both internally and toward suppliers.

5.4.1.1 Knowledge

A recurring theme from employees relates to understanding the intentions of APQP and PPAP. While employees showed awareness of the processes mainly reflecting the “what”, it is unclear to what extent they have understood the underlying foundation of the framework including its purpose, logic and practical application - being the “why” and “how”. For instance, this was noted by an SQM employee who exemplified a type of misunderstanding when employees believe that PPAP approved parts cannot fail. This misbelief represents a fundamental gap that PPAP is a guarantee of quality when it is the documentation of risk reducing processes, which illustrates the difference of “what” people think and “why” it exists. The “how” aspect of this knowledge gap was also revealed in a comment from an R&D employee, who described APQP deliverables as too vaguely defined to act on confidently. In the discussion of a specific deliverable the employee stated: *“I don’t really know exactly what I’m supposed to do. It might just as well be something that SQM is supposed to handle”* (R2). Firstly, this indicates an insufficiency in actionable guidance where role specific direction is absent. Secondly, it suggests a pattern of passive engagement amongst employees, which is particularly noted in the functions of R&D, logistics, and procurement, while SQM commonly maintains high understanding of processes partly due to formal responsibility. As a result, SQM frequently carries an uneven share of responsibility of other functions, which disrupt the cross-functional balance intended by the APQP structure (Stamatis, 2018).

While the remark about deliverable unclarity may not reflect a critical issue among experienced employees it was noted as more critical for those with less experience: *“... if you’ve been involved before, you know what the next step is without having to look it up. But if you’re new, it (guidelines) can be helpful”* (R2). In parallel, when considering the current training material of APQP, it was noted that this was mainly adopted and used in its original form from the affiliate OEM, while also being fragmented rather than systematically cohesive. These findings indicate that the APQP and PPAP training currently is non-standardized at the OEM where the learning relies heavier on peer guidance than structured onboarding. One SQM employee further confirms the need of more training among personnel, highlighting the importance of structured to handle larger functions: *“... but for R&D, they have a few hundred employees. It’s very hard to organize the workshop at the same time for all the employees”* (S4). This highlights a broader challenge in how knowledge is managed and transferred at the OEM. Linderman et al. (2004) argue that effective quality management should not only enforce compliance but actively support knowledge creation within the organization. Drawing on Nonaka’s concept of *externalization* (Linderman et al., 2004), knowledge creation involves articulating tacit know-how to make it explicit, integrate it into collective systems, and continuously refining it through experience. The current reliance on informal learning and peer guidance may serve experienced staff but risks inconsistency and inefficiency for newer employees. Without formal mechanisms to capture and standardize experiential insights, the “how” and “why” behind process steps, knowledge remains fragmented and dependent on individual actors. This undermines the potential of APQP and PPAP as strategic processes for cross-functional alignment and continuous improvement.

5.4.1.2 Supplier

A parallel observation was made regarding suppliers, where employees noted clear performance differences between experienced and inexperienced suppliers. As experienced suppliers appear to rely heavily on tacit knowledge gained through previous collaborations and practical experience, these suppliers tend to anticipate expectations and deliverables more effectively, even when formal APQP and PPAP

instructions are unclear. Less experienced suppliers often require repeated clarification, suggesting that they lack access to the same embedded know-how. This points towards the OEM's reliance on experience over process clarity. While trust in supplier familiarity can temporarily compensate for gaps in formal training or documentation, it introduces risk when personnel or supplier relations change. To ensure consistent performance across the supplier base, the OEM would benefit from increasing intangible investments in terms of supplier knowledge. As emphasized by Lee & Li (2018) and (Bai & Sarkis, 2016a), such intangible investments could improve supplier capability, reduce dependency on individuals, and support long-term quality performance.

In addition to inexperienced suppliers, another employee emphasized that physical presence at the supplier site has an important role in establishing a mutual understanding. Being on-site is seen as valuable not only for verifying processes, but also, for enabling two-way communication and ensuring that both parties clearly understand expectations. However, as such visits are limited due to time and cost constraints, maintaining that level of alignment has become more difficult. In the absence of physical presence, communication tends to be limited to basic documentation such as pictures or short process descriptions. This finding suggests a communication gap from less real time interaction in which the two-way dynamic is affected. As Verhoeven (2023) pinpoints, the current standard communication tools in the industry, such as email and disconnected software, do not effectively support interactive engagement between parties. With this standard, communication becomes delayed, hindering the flow of ideas and reducing clarity (Verhoeven, 2023). While Verhoeven (2023) reinforces the strength of physical presence, the limitation in onsite visits suggest a need for better digital channels. Therefore, the findings highlight the need for developing standardized remote training. By formalizing this support, the OEM can continue to build effective supplier relationships even when direct contact is limited, reducing the reliance on informal exchanges to fill knowledge gaps.

5.5 Summary of Analysis

As per the CMMI capability analysis, a set of key gaps have been identified for each process area, as seen in *Table 10*. These key gaps are important to address in the progression towards higher capability levels.

Table 10 – Identified Key Gaps Per Process Area

Category	Process Area	Gap(s)
Project Management	Project Planning	<ul style="list-style-type: none"> • Gate compliance • A need for organizational support to the cross functional team
	Integrated Project Management	<ul style="list-style-type: none"> • Ambiguities in task ownership • Alignment of logistics and procurement • Supplier integration
Process Management	Organizational Process Definition	<ul style="list-style-type: none"> • Fragmented approaches to tracking APQP • APQP deliverables not fully tailored • Work standardization
	Organizational Training	<ul style="list-style-type: none"> • Incomplete understanding of APQP and PPAP • Non-standardized training • Supplier training

5.5.1 Project Planning

Despite a structured planning model in place through APQP, several patterns indicate that projects are not always executed according to plan. Two primary gaps are observed.

5.5.1.1 *Gate compliance*

Project phases are sometimes advanced prematurely, before all relevant tasks, particularly verification, are properly completed. In the pursuit of meeting tight deadlines, including influence by top-down scheduling pressure, process discipline tends to be compromised, and processes start to deviate from planning. This lowers the rigor of execution and increases the risk of issues surfacing downstream, where correction becomes significantly more costly. The result is an imbalance in the project priorities, where emphasis on the time objective leads to trade-offs in both quality and cost.

5.5.1.2 *A need for organizational support to the cross functional team*

The current cross functional team lacks sufficient support on component level to help coordinating planning and decision making. While a launch management structure exists, it operates at a distance from daily execution, thus making it difficult for the teams to get timely guidance. As a result, there is an expressed need for a middle-management role to support the cross-functional team by balancing interdepartmental priorities, challenging premature phase progression, and reinforcing process discipline.

5.5.2 Integrated Project Management

While several employees have expressed that the current collaborative efforts are adequate to ensure APQP and PPAP progress, the findings point to a few gaps between an ideal and the current state of IPM. In advancing between capability levels, the OEM would benefit from ensuring an aligned, digital approach, where roles and responsibilities are clear, both for employees and suppliers. Further, addressing the involvement of procurement and logistics would aid in strengthening cross-functional coordination. Lastly, ensuring increased supplier integration would aid in getting a representative view of APQP and PPAP progression.

5.5.2.2 *Ambiguities in Task Ownership*

As expressed by several employees, and supported by internal documentation, there are inherent gaps in task ownership for both APQP and PPAP (although mainly for APQP). These gaps encompass that deliverables in APQP are performed by SQM employees, although formally assigned to other functions. While this approach may work in practice, it can lead to a heavy workload for SQMs, leading to varying quality in deliverables. Further, when other functions are not sure what their formal assignments are, they tend to be reactive towards SQM employees. Also, when the roles surrounding the digital applications are not thoroughly defined, there is a risk of inconsistencies and missing information. Ensuring a defined responsibility structure is foundational for reaching the higher CMMI levels, indicating a need for prioritizing the closing of this gap.

5.5.2.3 *Alignment of Logistics and Procurement*

Although the overarching involvement of logistics and procurement in APQP and PPAP is limited, there is currently a gap in their alignment. Although they are not directly involved in PPAP elements, their expertise has the potential of increasing the quality of work through introducing further views. Further, increasing their involvement both system- and interaction-wise would help with fostering better

collaboration through employee engagement. While the current misalignment stems from several factors such as resource prioritization, a slim logistics function and an ongoing digital transition, CMMI level two emphasizes the engagement of relevant stakeholders.

5.5.2.4 Supplier Integration

While the performance of suppliers mostly seems to depend on their experience, the findings suggest that further integration would be beneficial. As both APQP and PPAP are complex processes, encompassing thorough OEM-specific requirements, it is vital to ensure continuous communication and clear expectations. Doing so would aid the progression of IPM maturity and ensure better collaboration with suppliers.

5.5.3 Organizational Process Definition

While foundational process documentation and templates exist for both APQP and PPAP, the current organizational approach presents opportunities for strengthening consistency, as the current ways of working often face variability because of individual interpretations and preferences. To progress towards higher CMMI capability levels, the OEM would benefit from refining and reinforcing how process assets are defined, communicated, and applied across the organization.

5.5.3.1 Fragmented Approaches to Tracking APQP

Currently, there is not a unified way of working with APQP at the OEM. While employees situated in Asia mainly use excel for tracking progress, employees in Europe use an APQP application. Ensuring an organization-wide approach to digitally tracking APQP would aid the OEM in reaching level two for OPD, as per CMMI (Chrissis et al., 2011). In having a centralized approach, the OEM can ensure a single source of truth and a benchmark from which other improvements can be implemented.

5.5.3.2 APQP Deliverables not Fully Tailored

While the current structure of APQP deliverables provides a strong foundation for ensuring traceability, there is an expressed need for further tailoring the deliverables towards how the OEM works. In navigating the current deliverable structure, it was apparent that not all deliverables are used today, and the deliverables that are used could benefit from a refined description. In moving towards CMMI capability levels two and three, ensuring documented APQP deliverables that correlate with practical execution is a key action.

5.5.3.3 Work Standardization

Despite the varying nature of both APQP and PPAP, employees emphasized the need for greater standardization across these processes. Clarifying the relationship between the two would help teams understand how early APQP activities contribute to PPAP outcomes. Additionally, establishing clear guidelines for documenting progress and performance, conducting meetings, and managing project variability would support the OEM in advancing its OPD capability.

5.5.4 Organizational Training

Although general awareness of APQP and PPAP exists across the organization, training practices remain informal, and experience based. The following gaps reveal the impact of this on internal performance and supplier collaboration.

5.5.4.1 Incomplete understanding of APQP and PPAP

Employees show general awareness of APQP and PPAP but show signs of varying understanding of the overall purpose, applications, and role-specific responsibilities. The functions of R&D, logistics and procurement are significantly subject to this variability. This gap of understanding results in not seeing the importance of APQP and PPAP processes and further puts an imbalance to the APQP structure. As a result, SQM are seen taking on a disproportionate responsibility, while remaining functions sometimes become passive awaiting SQM to lead the processes.

5.5.4.2 Non-standardized training

While general APQP and PPAP training material exist, it is noted to be directly adopted from the affiliate and further appear fragmented. Training is not seen highly invested in today and experience plays a key role in success, which suggests that training has not yet been standardized. Although this approach may work for smaller functions like SQM, the approach raises difficulties in scaling for larger functions, especially those inexperienced with the processes. This highlights the need for higher standardization to align the understanding of APQP and PPAP and reduce the gap of experienced and inexperienced personnel.

5.5.4.3 Supplier training

Supplier performance often depends on prior informal experience rather than clear, structured onboarding. Less experienced suppliers require repeated clarification, revealing a gap in formal training and consistent communication routines. As a lot of expectations are put on suppliers, it is evident that they understand the expectations from the start. This highlights the need to further invest in supplier training for a deeper understanding of APQP and PPAP which may benefit the mutual expectations.

6. Discussion

This chapter reflects on the findings of the study in relation to both the theoretical framework and the practical context explored throughout the thesis. The discussion of theoretical implications highlights the study's contribution to existing research, while the managerial implications aim to address the identified challenges. Finally, the limitations of the study are outlined along with suggestions for future research.

The aim of this study was to investigate how a global OEM utilizes APQP and PPAP in component industrialization, with the purpose of identifying opportunities for streamlining the use of these processes. By applying CMMI as a process maturity framework, the study sought to identify key challenges and gaps in the current practices. The research was guided by three questions: how the maturity of APQP and PPAP can be evaluated using CMMI, what gaps influence their application, and what actions can support the advancement of their process capability.

Building on the empirical findings, this study offers two overarching contributions of broader relevance to the field of quality and operations management. First, it provides an account of how APQP and PPAP are operationalized within a global OEM, identifying key challenges related to cross-functional alignment, routinized practices, system integration, and knowledge management, areas previously emphasized as critical for sustained QM (Fonseca, 2015; Weckenmann et al., 2015). Second, by applying a process maturity perspective, the study reinforces the understanding of quality as an organizational capability rather than a technical concern (Ebrahimi & Sadeghi, 2013; Hoyle, 2011). These contributions are further developed in the following sections.

6.1 Theoretical Implications

This study contributes to research by positioning APQP and PPAP as an interdependent framework for component industrialization, rather than as isolated compliance processes. In this context, interdependent refers to the way in which selected outputs from APQP are directly related to PPAP, establishing a functional link between the two processes. By examining their collective application through the lens of process maturity, the study extends theoretical understanding of how quality management systems can be evaluated and developed with respect to cross-functional collaboration, supplier integration, work standardization, and digital enablement. Grounded in a case study at a global OEM, the findings contribute to research on both APQP and PPAP. The notion advanced by Rocha & Salerno (2014) that APQP can jeopardize product development if not applied consistently has been both validated and expanded in this study. The findings confirm that inconsistent task ownership, varied use of digital applications, and limited cross-functional coordination contribute to rework, reduced transparency, and reactive decision-making. Moreover, the study extends Rocha & Salerno's (2014) claims by highlighting the importance of formalizing both internal and external collaboration to support effective APQP execution. In parallel, Gawlik et al. (2012) attribute PPAP-related issues to premature approvals and a lack of understanding of the process and its verification logic. This study builds on that insight by demonstrating how such deficiencies often correlate with APQP challenges. In doing so, it underscores the need to approach APQP and PPAP as a cohesive system shaped by organizational maturity and process integration.

In applying the CMMI framework as defined by (Chrissis et al., 2011), this study contributes to the broader field of business process maturity by demonstrating the framework's relevance beyond its original empirical application area, more

specifically in contexts outside the IT domain. It also reinforces the applicability of CMMI in the context of SQM, as proposed by Ho et al. (2016), by showing how CMMI can be used diagnostically to assess and guide the improvement of SQM processes. This study illustrates how process areas such as Project Planning (PP), Integrated Project Management (IPM), Organizational Process Definition (OPD) and Organizational Training (OT) can inform the evaluation of APQP and PPAP practices, thus underlining the value of using maturity frameworks not only for benchmarking but also as structured guides for organizational improvement.

The theoretical SQM framework, incorporating inspection, investment, and collaboration, shows several correlations with the findings on APQP and PPAP. Both APQP and PPAP are intended to reduce reliance on physical inspection by promoting structured buyer–supplier relationships, supported by supplier incentives such as training and funding. These findings emphasize the importance of practices such as intensive communication, investment in high-quality tooling, targeted training, and the formalization of relationships (Flynn & Flynn, 2005; Lee & Li, 2018; Noshad & Awasthi, 2015).

While PDCA forms the foundation of AIAG’s APQP structure (AIAG, 2008), this study offers empirical observations of how its iterative logic is applied in practice. The findings suggest that while planning and execution are generally embedded in APQP, project follow-up is less consistently institutionalized. Although not a primary theoretical focus, the study further touches on how delivery pressures can influence the balance between quality assurance and project timelines, building upon the Triple Constraint and FTR (Pollack et al., 2018; Poppendieck, 2002). These insights contribute to quality management literature by illustrating how project management and clear roles influence the effectiveness of quality management frameworks.

6.2 Managerial Implications

To address the gaps identified in the analysis, a set of actions and complementing steps has been developed with the aim of enhancing the effectiveness and integration of APQP and PPAP practices. These actions are grounded in the CMMI framework and structured to support both immediate and strategic capability development. While the actions are targeted toward distinct process areas, their interdependence means that improvements in one area often generate positive effects in others. For instance, clarifying APQP deliverables can not only enhance individual understanding but also strengthen cross-functional alignment. Further, the actions are structured based on their feasibility and implementation timeline, categorized as either short-term or long-term.

The actions proposed in the following section are derived from the empirical findings and subsequent analysis. While they are intended to address observed challenges and gaps, they should not be interpreted as definitive solutions. Rather, they represent contextually grounded suggestions that may support the continued development of APQP and PPAP practices, primarily for the case company. As with any improvement initiative, adaptation to organizational conditions and stakeholder needs may be required prior to implementation. Actions have been categorized as short- or long-term based on estimated resource requirements. Short-term actions are considered feasible to implement using existing resources, whereas long-term actions are expected to require additional resources and broader organizational commitment.

6.2.1 Short-term Actions

The short-term actions focus on addressing gaps that can be mitigated under the current organizational structure through operational adjustments and clarification of responsibilities. These actions are deemed feasible to implement within a limited timeframe and are intended to provide immediate improvements in performance, alignment, and system usability without requiring larger organizational changes or resources.

Action 1: Ensure Digital Alignment

To ensure a consistent and structured approach to APQP, the OEM should align under one common tool, minimizing the use of excel to track progress. This alignment will enable better traceability, reduce variability in working methods, and support process standardization across functions and regions. Since the APQP application is already used by several SQM employees, it is assumed that this implementation is feasible within a short time frame. In ensuring a unified approach, it is important to further define digital responsibilities and conduct foundational training.

While the underlying process of conducting APQP is the same for the digital application and excel, there is a need for specifying who is accountable for inserting, reviewing and validating data at different project stages. This includes defining what actions are expected from roles such as SQM, R&D, procurement and logistics to ensure consistency.

Prior to requiring the usage of the APQP application, foundational training is needed to support the baseline usage of the applications. This training should cover key system functionalities, the user interface and collaboration practices. To aid the short-term transition towards digital alignment, foundational training can be completed initially, with in-depth training developed later.

Action 2: Redefine Task Ownership Using RACI Matrix

To ensure clear task ownership across cross-functional teams, the usage of a *Responsible, Accountable, Consulted* and *Informed* (RACI) matrix is suggested. As per Goos et al. (2012), a RACI matrix gives a clear overview of who performs the work (R), who approves it (A), whose opinion is sought (C), and who should be informed (I). Since suppliers usually perform tasks, the use of the R dimension will generally not be applicable, ensuring easier assessment. Through workshops and/or internal questionnaires, RACI matrices could be used both for APQP deliverables and PPAP elements in line with *Table 11*.

Table 11 – Example of How a RACI Matrix Could be Used

Deliverable\ Role	SQM	R&D	Procurement	Logistics
1	A	R	C	I
1.1	C	C	I	A
2	C	A	I	I

Action 3: Enhance gate discipline

Strengthen gate discipline by ensuring that gate reviews include more rigorous validation requirements. Project phases should not advance unless all deliverables are both formally completed and technically validated. Rather than relying solely on documented status, the review process should include clear evidence of functional readiness. This will help ensure that each project phase meets its intended quality and maturity targets before moving forward, reducing the risk of late-stage issues, unnecessary costs, and deviations from the APQP structure. This action may be governed by SQM engineers who are currently seen as leading the APQP process.

Action 4: Modular supplier training

Complement the supplier agreements with modular training material that sections out critical information and expectations from the OEM based on gates. Training material for each module can then be repeated on a frequent basis towards suppliers throughout phases to reemphasize critical information. This approach will facilitate an iterative learning curve amongst the new supplier to ensure faster and deeper understanding of expectations without being perceived as an information overload.

6.2.2 Long-term Actions

The long-term actions focus on addressing structural and systemic improvements that extend beyond immediate operational adjustments. These actions require organizational alignment, resource planning, and structural reinforcement to ensure sustainable improvement of APQP and PPAP maturity. While implementation may span a longer timeframe, these initiatives aim to embed standardized practices, strengthen cross-functional support, and formalize training and integration, ultimately enhancing long-term efficiency and capability across the organization.

Action 1: Introduce Component Owner for Cross-Functional Support

To reduce the risk of issues being deferred to later phases, the OEM should strengthen organizational support for managing cross-functional challenges. This could be achieved by introducing a component owner as an additional support role within the current team. The component owner would serve as an operational point of contact, supporting cross-functional decision-making from a neutral perspective while helping to maintain timeline alignment. In addition, the role would enhance the escalation process by providing the cross-functional team with quicker responses to emerging concerns. This would reduce the likelihood of postponing issues and, at the same time, ease the burden on the launch management team by filtering out less critical matters that could be addressed at the operational level.

Action 2: Address the Involvement of Buyers and Logistics

To strengthen the contribution of logistics and procurement employees in the industrialization process, a formalized involvement structure should be established. While their current engagement is often limited due to resource constraints and prioritization, clearer and more consistent involvement would support smoother cross-functional collaboration and reduce administrative overhead for SQM. If increased participation in process or supplier interactions is not deemed feasible, their involvement should instead be defined in a way that minimizes the need for their continuous meeting presence while still ensuring that their input is captured.

In the transition toward fully digital APQP and PPAP workflows, it is essential that both logistics and procurement employees are granted access to the relevant applications. This would enable them to follow progression in real time, add documentation, and provide comments where applicable. Increased visibility and input capabilities would reduce the need for repeated clarification, ease the burden on SQM to coordinate updates manually, and enhance traceability across functions.

Action 3: Function-Specific Training

Introduce role-specific training as a complement to current training material. This training material should focus on deeper learning and understanding of deliverables, expectations, and ownership for each function. The purpose of the role-specific training is to clarify responsibilities for each role and support the employees in driving the process forward actively.

Action 4: Ensure Digital Connectivity Between APQP and PPAP Applications

In moving towards a digitally aligned SQM organization, ensuring an efficient system that minimizes the impact of human error is important. Ensuring that the progression of APQP deliverables is reflected in the PPAP application is a vital step towards decreasing administrative work, increasing transparency and aiding a single source of truth. To further improve system automation, the connectivity should be complemented with triggers such as mail notifications.

When an APQP deliverable is checked and it has a corresponding PPAP element, both should be marked as completed, and a trigger should notify relevant stakeholders. These triggers could either be solely information-based (progress updates), or action-based (prompts to act, such as upload documentation). Relevant stakeholders could either be decided through a subscription-based setup, where users subscribe to be notified of specific component progression, or through a formalized setup, where a manager or SQM employee assigns these triggers

Action 5: Reduce Deliverables

To ensure better compliance in fulfilling APQP steps, the current deliverables should be revised and optimized for higher relevance of deliverables. The aim should be to reassess current deliverables together with the respective responsible functions to distinguish between value filling tasks that are currently used and nonapplicable ones that may be perceived as excessive documentation. While some deliverables might be eliminated others might be reduced to reduce repetition. The revision of deliverables should help the cross-functional team by increasing relevance and thereby employee's motivation to properly fulfill deliverables, which includes committing both to practical procedure and documenting them in the digital system.

Action 6: Clarify Deliverable Descriptions

The deliverable descriptions should be rewritten for clarity and comprehensibility to ensure that the reader know how to apply and proceed with the task. This would promote active ownership of deliverables and reduce a passive work approach especially among inexperienced employees who rely on task descriptions rather than on prior experience.

Action 7: Formalize Continuous Improvement

In line with the two PDCA phases of "Check" and "Act" foundationally incorporated in AIAG's APQP model, the process of capturing best practices should be formalized. As both APQP and PPAP are extensive processes, it could be beneficial to see the value in gradual, small-scale improvement over large-scale restructuring. Whether it regards continuously redefining deliverables or capturing knowledge, having a routine for embedding these into the organization may prove valuable.

6.2.3 Summary of Suggested Actions

The suggested actions, without a defined order, have been summarized in *Table 12*. Through these actions, an OEM may improve APQP and PPAP process maturity towards higher CMMI capability levels (Chrissis et al., 2011).

Table 12 – Summary of Recommended Actions

Time Frame	Action	Process Area
Short-term	Ensure Digital Alignment	IPM
	Redefine Task Ownership Using RACI Matrix	IPM, OPD
	Enhance Gate Discipline	PP
	Modular Supplier Training	OT
Long-term	Introduce Component Owner for Cross-Functional Support	PP
	Address the Involvement of Procurement and Logistics	IPM, PP
	Function-Specific Training	OT
	Ensure Digital Connectivity Between APQP and PPAP Applications	IPM
	Reduce Deliverables	OPD
	Clarify Deliverable Descriptions	OPD
Formalize Continuous Improvement	ALL	

6.3 Limitations and Future Research

Since the study is based on a single OEM the findings are closely tied to this specific context. While this case provides detailed insights into how APQP and PPAP are applied in practice, it also limits the ability to generalize the results to other organizations that may operate under different conditions or use other systems. The company-specific nature of the findings should therefore be considered when applying the insights beyond this setting. Moreover, as the OEM is currently undergoing an organizational transition, the research was conducted under dynamic circumstances. The ongoing changes, which affect both digital systems and the structure surrounding APQP and PPAP, create a degree of uncertainty regarding the long-term applicability of the findings. This transitional context may also influence the trustworthiness of certain insights, as processes and roles described during interviews may continue to evolve beyond the scope and duration of this study.

Another limitation of this study is that the supplier perspective of APQP and PPAP was captured solely through the lens of the OEM. While this provided valuable insight into how internal functions perceive and interact with suppliers, it does not fully reflect the suppliers' own experiences, challenges, or interpretations of the requirements. The research has also had a prior focus on Tier 1 suppliers, meaning that the perspectives and challenges of sub-suppliers remain unexplored. This internal and Tier 1-focused perspective may overlook important dynamics and operational barriers deeper in the supply chain. Thus, to build a more comprehensive understanding the future research should directly engage with both Tier 1 suppliers and sub-suppliers to explore how they experience the OEM's expectations, documentation demands, and processes. This would help validate the OEM's internal views and identify improvement opportunities from multiple perspectives. Incorporating the supplier perspective could reveal misalignments between intended and perceived requirements, uncover practical challenges in fulfilling APQP and PPAP tasks, and highlight areas where communication, training, or system design may require further refinement.

Additionally, for future research a broader perspective of APQP and PPAP should be explored to cover the full perspective of industrialization seen at a project level rather than limiting the scope to component level. While component level insight has given this research depth, a wider scope would provide additional insight into the necessary collaboration across the cross functional teams in industrializing a vehicle.

7. Conclusion

This thesis set out to examine how a global OEM applies APQP and PPAP as part of its SQM efforts. Using a case study approach supported by interviews, internal documentation, and insights from key informants, the study identified challenges encountered in these processes and the gaps between current practices and formalized procedures. To structure the analysis, the CMMI framework was applied, enabling a systematic assessment across four selected process areas: Project Planning (PP), Integrated Project Management (IPM), Organizational Process Definition (OPD), and Organizational Training (OT). These areas provided a focus through which to explore core themes such as project execution, cross-functional collaboration, work standardization, and knowledge.

The analysis revealed that while APQP and PPAP are formally established and supported by digital tools, enabling effective component industrialization, their application varies across functions and regions. Key challenges include variations in task ownership, limited involvement from functions beyond SQM, and the absence of a unified digital approach. Additionally, process execution often deviates from the intended structure due to time pressure and constrained resources. When mapped to the selected CMMI process areas, these issues highlighted specific gaps, including the need to tailor APQP deliverables, improve knowledge transfer, and align system usage across the organization. Addressing these areas presents an opportunity to advance process maturity and foster a more consistent and efficient approach for SQM.

This thesis contributes to the theoretical understanding of how maturity models such as CMMI can be applied beyond their traditional domains in software and IT, offering company-specific insights into SQM. By evaluating APQP and PPAP through the CMMI framework, the study demonstrates how process maturity frameworks can be leveraged to diagnose organizational performance in cross-functional, compliance-driven contexts. In addition to presenting a structured approach for assessing quality planning and approval processes, the findings reinforce the relevance of maturity-based frameworks in quality and operations management research. This study extends existing knowledge by showing how capability assessments can reveal underlying gaps in complex frameworks such as APQP and PPAP, particularly in relation to knowledge management, cross-functional collaboration, and process standardization.

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Appendix A – The Five Phases of APQP

Phase 1: Plan and Define	The first phase of APQP encompasses defining customer requirements and expectations connected to the design or redesign of the product. Integrating the Voice of the Customer (VoC) through data and information collection helps form the requirements needed to define the quality program (Stamatis, 2018) ² . Through this phase, parties create a preliminary plan of goals and processes, before design engineers start drafting.
Phase 2: Product Design and Development	Following the direction from phase one, the goal of the second phase is to design the product and assess its feasibility. Ensuring that the product can be manufactured and fulfill its intended purpose is important to prevent costly revision in later phases.
Phase 3: Process Design and Development	When the product is designed and defined with respect to material specifications, equipment requirements and risk assessment, the third phase covers the planning of manufacturing the new or redesigned product. Key considerations of this phase include product specifications, quality and costs when developing the production process. In addition to producing the product within tolerances, the process needs to produce the number of required products.
Phase 4: Product and Process Validation	To validate the final product and the means of producing it, phase four encompasses rigorous testing of both. Through trial production runs, the reliability and capability of the process as well as the product quality acceptance criteria can be confirmed. Any adjustments needed are made before moving on to the final phase.
Phase 5: Feedback, Assessment and Corrective Action	During the fifth and final phase, full-scale production with a focus on assessing and enhancing processes begins. Key activities include minimizing process variations, identifying potential issues, and implementing corrective actions to drive continuous improvement.

² Stamatis, D. H. (2018). Advanced product quality planning (APQP) and control plan. CRC Press. <https://doi.org/10.1201/9780429401077>

Appendix B – PPAP Elements Explained

<p>1. Design Record The design record is the blueprint for the saleable product. By stating the dimensions, tolerances, material and other requirements of the product, the buyer can communicate what the supplier needs to do. Regarding material composition, suppliers need to validate their material choices through systems such as the International Materials Data System (IMDB), which lists hazardous and forbidden materials. Further requirements are needed for polymeric materials.</p>
<p>2. Authorized Engineering Change Documents For any changes made to the product, part or tooling not incorporated in the design record, the supplier shall have authorized engineering change documents that declare this.</p>
<p>3. Customer Engineering Approval In line with buyer requirements, there should be evidence of engineering approval on the buyer side. The engineering approval underlines that the buyer has understood the resulting specifications of the component and takes responsibility for the technicalities.</p>
<p>4. Design Failure Mode and Effects Analysis The Design Failure Mode and Effects Analysis (DFMEA) is a methodology used to prevent potential failures in product development. DFMEA encompasses several steps, ranging from detecting potential failures to evaluating their severity. By listing several potential failures and their respective severity, R&D teams may understand where resources should be invested to prevent rework and delays.</p>
<p>5. Process Flow Diagram(s) Process Flow Diagrams (PFD) are flowcharts that show the relationship between components in a manufacturing plant, giving an overview of the production processes. The supplier shall create a PFD in line with buyer requirements that clearly states sequential production processes. These steps and sequences should meet the needs, requirements and expectations of the buyer.</p>
<p>6. Process Failure Mode and Effects Analysis (PFMEA) Like DFMEA, Process Failure Mode and Effects Analysis (PFMEA) is a methodology used to analyze potential failures related to operational processes.</p>
<p>7. Control Plan The control plan is a document that outlines the methods used to ensure quality control at a production plant. Through standardized procedures and routines, the control plan gives an overview of critical inputs and outputs to ensure compliant production. The supplier shall have a comprehensive control plan that defines all methods used for process control, in line with buyer-specific requirements.</p>
<p>8. Measurement System Analysis Studies The supplier shall perform applicable Measurement System Analysis (MSA) studies to ensure that all process variabilities are satisfactory. By using appropriate methods such as analysis of repeatability and reproducibility (R&R), bias, linearity and stability, suppliers can provide a measurement system capability assessment. This assessment declares whether the measurement system is qualified for use or not.</p>
<p>9. Dimensional Results In line with the design record (element 1) and the control plan (element 7), the supplier shall provide evidence that all processes are compliant with respect to dimensional tolerances and other buyer-specific requirements. One of the components measured within this element shall act as the master sample (element 15). The measurements used in this element shall be actual results and not approximations.</p>

<p>10. Records of Material / Performance Test Results The supplier shall have documentation of material and/or performance test results in line with tests defined in the design record or control plan. By defining how tests were conducted, a record can be kept and connected to the design record (element 1) and/or the authorized engineering change documentation (element 2).</p>
<p>11. Initial Process Studies Through initial process studies, the supplier demonstrates that critical processes are stable and operational with normal variation near the intended nominal value.</p>
<p>12. Qualified Laboratory Documentation All inspection and testing for PPAP needs to be done by a qualified laboratory, as defined by the buyer. Whether the laboratory is external or internal to the buyer, the laboratory needs documentation showing that it is qualified for the type of measurements and/or tests conducted.</p>
<p>13. Appearance Approval Report For every component that has appearance requirements from the buyer, the supplier needs to create an Appearance Approval Report (AAR) for each component or series of components. The AAR specifies the approval or non-approval of aesthetic factors such as colour, grain or surface appearance.</p>
<p>14. Sample Production Parts The supplier shall provide sample products in line with buyer requirements.</p>
<p>15. Master Sample The master sample serves as a benchmark for employees at the supplier site. As the master sample is approved by the buyer, it acts as a reference for compliant production results. Unless a new master sample is created, the supplier should retain the original master sample during the period of the production part approval records.</p>
<p>16. Checking Aids Checking aids encompass the tools used to measure the components. The supplier shall submit any checking aids used for the validation of dimensional requirements. These checking aids need to be validated through MSA studies, in compliance with customer requirements.</p>
<p>17. Customer-specific Requirements The supplier shall have documentation to show compliance with all applicable buyer-specific requirements.</p>
<p>18. Part Submission Warrant The main element of PPAP is the Part Submission Warrant (PSW). The PSW is the final document of PPAP - it serves as a write-off and summary of the component. When the PSW is signed by the supplier and buyer, the component has been industrialized and is ready to be used for full-scale production.</p>

Appendix C – Interview Guide

Introduction

- What is your name and role?

APQP

- From the perspective of your department, how do you work with APQP?
 - How do you use the current IT system related to APQP?
- What information(input) do you need to be able to successfully perform your tasks in APQP?
 - How is this information delivered to you?
 - Do you get all the information needed?
- How do you communicate throughout the APQP?
 - What communication channels do you use?
 - What do you think about them?
- How are the suppliers involved in your work with APQP?
- What do you think about your ways of working with APQP?
 - What is better?
 - What is worse?
- What deliverables do you see as most important to the APQP?
- What deliverables do you see as less important for the APQP?

PPAP

- How is your department involved in PPAP?
 - How do you use the current IT system related to PPAP?
- What do you think about your way of working with PPAP?
 - What is better?
 - What is worse?
- Other thoughts?

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