DEGREE PROJECT

Integration of Advanced Product Quality Planning in Quality Preparation for an Original Equipment Manufacturer in the Automotive Industry

A Case Study at Volvo Group Trucks Operations Powertrain Production in Skövde

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Industrial and Management Engineering, master's level
2023

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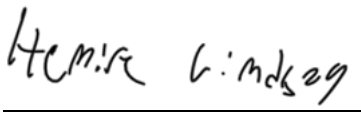
Acknowledgment

This master's thesis is the final stage of our five years of studying M.Sc. Industrial Engineering and Management with a specialization in Quality Management at Luleå University of Technology. This has been a challenging and rewarding experience working with Volvo Group Trucks Operations Powertrain Production in Skövde. We would like to express our gratitude to the Quality division for their support and especially thanks to Mattias Frisk, our supervisor at Volvo, who shared his expertise and assistance have been invaluable in helping us navigate the complexities of this topic. We would also like to thank our supervisor at Luleå University of Technology, Mahdieh Sedghi, who helped us with valuable insights and support when we needed guidance. Finally, we would like to acknowledge the contributions of our opponents Karl Ericsson, Erik Hilmersson and Gustav Sjöberg. Their feedback and discussions have helped us refine our ideas and improve the quality of our work.

Thank you all for the support and valuable contributions to this master's thesis. We are grateful for the opportunities and experiences that this project has afforded us, and we look forward to continuing to build upon these foundations in our future work.

Hanna Gertsson
Skövde 2023-06-11



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Skövde 2023-06-11

Division of Work

This report has been jointly authored by two individuals who have divided the workload equitably. The authors have collaborated to determine the contents of the report to ensure coherence, and both have contributed to writing its sections. However, the authors have allocated responsibilities as follows;

Area	**Responsible**
1 Introduction	Henrik Lindberg
2 Business overview	Hanna Gertsson
3 Review of Literature	Hanna Gertsson
4 Research Methodology	Henrik Lindberg
5 Empirical Findings	Henrik Lindberg
6 Analysis	Hanna Gertsson
7 Conclusion and Recommendation	Hanna Gertsson
8 Discussion and Contribution	Henrik Lindberg

Abstract

This study examines the development of Volvo Group Trucks Operations Powertrain Production (Volvo GTO PTP) in Skövde, focusing on the implementation of processes for new products intended for both internal and external customers. Previously, the company solely supplied products within the Volvo Group, functioning as an Original Equipment Manufacturer (OEM). With the opportunity to adhere to the supplier-specific quality standard IATF 16949:2016, an extension of the ISO 9001:2015 quality standard. Volvo GTO PTP aims to enhance product and process development through the adoption of the Advanced Product Quality Planning (APQP) method. Unlike the existing project models, Develop Product and Aftermarket Product Portfolio (DVP) and Project Steering Model (PSM), used by Volvo GTO PTP, the APQP method validates product and process development together.

This study investigates the relationship between the current project models, DVP and PSM, and the APQP model, identifying areas within APQP that require further development. Interviews and thematic analysis were conducted to assess the current state of APQP, with an evaluation matrix employed for quantitative analysis. Findings reveal a knowledge gap within Volvo GTO PTP, wherein comprehension of APQP activities and their correlation with DVP and PSM is lacking. Critical activities for execution and management within the APQP model include measurement system analysis (MSA), checking aids, records of customer-specific requirements, part submission warrant, and Production Part Approval Process (PPAP). Furthermore, organizational culture-related deficiencies contribute to the difficulties in adopting a holistic project perspective due to siloed working practices.

The integration of APQP in the existing project models is recommended to Volvo GTO PTP in Skövde, as many APQP activities are already established or easily implementable. This integration facilitates the clear definition and demonstration of interplay between different project models, clarifying deliveries and the release of product and process development. To avoid reactive approaches to problem management, it is advisable to explicitly define responsibility for risk management and activities within the APQP model. The demand for APQP activities emphasizes their interconnectedness and creates a natural flow within the project model, contributing to an improved organizational culture and understanding of APQP. Ultimately, the APQP model establishes favorable conditions for reducing quality-related costs during the introduction of new products and product changes, ensuring appropriate preparedness in quality management. Compliance with IATF 16949:2016 also offers Volvo GTO PTP in Skövde the opportunity to obtain certification.

Key Words: Advanced product quality planning (APQP), quality preparation, production part approval process (PPAP), IATF 16949, ISO 9001, automotive industry, gap analysis, change management, risk management, product development and process development.

Abbreviation

Abbreviation	Stands for
APQP	Advanced Product Quality Planning
DFMEA	Design Failure Mode and Effects Analysis
DVP	Develop Product & Aftermarket Product Portfolio
FMEA	Failure Mode and Effects Analysis
IATF	International Automotive Task Force
MSA	Measurement System Analysis
OEM	Original Equipment Manufacturer
PFMEA	Process Failure Mode and Effect Analysis
PPAP	Production Part Approval Process
PSM	Project Steering Model
QMS	Quality Management System
VPS	Volvo Production System

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1 Introduction

This section presents an introduction to the report with the purpose and limitations of the project.

1.1 Background

Companies are becoming more aware of the need to review their supply chains as society undergoes rapid changes and stakeholders demand sustainable solutions for the products and services offered by these companies. Customer requirements can be addressed through proactive approaches to reduce waste caused by quality issues. A proactive approach means preventing problems before they occur rather than dealing with them reactively after they have arisen, which is a reactive approach (Illes et al., 2017, chapter 2.2). Quality management systems (QMS) are crucial aspects for working more proactively and achieving desired quality and continuous improvements.

Establishing the right conditions for QMS leads to increased customer satisfaction and defect reduction (Aggelogiannopoulos et al., 2007; Bergman & Klefsjö, 2020). Limitations of quality preparation include the requirement for clear structure to avoid missing important activities that affect project outcomes and delivery requirements. This study is a collaboration with Volvo Group Trucks Operations Powertrain Production (Volvo GTO PTP) in Skövde, specializing in foundry, machining, and assembly. The company experiences a reactive approach to problem-solving in their projects, meaning not considering and addressing problems early in the projects instead handling problems after production starts. As a consequence, projects become time-pressured as resources are redirected to meet launch dates. Quality deficiency costs increase at launch due to the failure to address issues related to methods, materials, and human factors. Thus, the economic goals are exceeded, and much of it is attributed to the lack of consideration for quality preparation in product and process development during the project period.

Volvo GTO PTP works with two project models: Develop Product and Aftermarket Product Portfolio (DVP), which focuses on product development and resembles Cooper's (2017) stage-gate model, and the Project Steering Model (PSM), which deals with process development and is tailored according to project requirements (Tonnquist, 2021). These project models are undergoing significant transformation as Volvo GTO PTP starts developing new products in their operations. The company's transformation is driven by a forecast indicating reduced demand for current products. The company has been producing engines since 1907. With this transformation, an opportunity arises for the company to supply products to external customers.

Volvo GTO PTP in Skövde is considered an Original Equipment Manufacturer (OEM), which refers to a company that produces products using components from external or internal

manufacturers (Merriam-Webster, n.d.). By starting to serve external customers, the company faces new customer requirements that enable them to be certified by the quality standard IATF 16949:2016. This quality standard is specific to the automotive industry and builds upon the general quality standard ISO 9001:2015 (DNV, n.d.; IATF, 2022). IATF 16949:2016 offers more flexibility compared to other quality standards in terms of market, customer service, operational performance, employees, and technology (Laskurain-Iturbe et al., 2021). Furthermore, IATF 16949:2016 focuses on customer requirements and waste reduction (IATF, 2022; Ruswanto & Saroso, 2018). A study on how certified OEM companies meet customer requirements showed that 90% of the IATF 16949:2016-certified companies meet customer demands compared to 73% of companies solely using ISO 9001:2015 (IATF, 2022). In the quality standard IATF 16949:2016, it is recommended to follow Advanced Product Quality Planning (APQP), which is an approach that enhances productivity while achieving high potential quality improvement (Mittal et al., 2012). APQP creates efficiency and conditions for companies to plan the quality of product and process development (IATF, 2016; Mittal et al., 2012). This means that companies can validate the product and process simultaneously rather than separately.

1.2 Problem definition

The challenge for Volvo GTO PTP is that the current project models, DVP and PSM, release for serial production separately, and there is uncertainty in the deliveries between the current project models. Volvo GTO PTP has adapted the APQP model to fit their operations and has implemented it in their current projects. However, there is a lack of understanding of how this project model is established and the significance of its activities. Therefore, this study aims to investigate the relationships between current project models, DVP and PSM, and the APQP model to assess the feasibility of meeting the requirements of IATF 16949:2016.

The transformation faced by Volvo GTO PTP has an impact on the company culture and change initiatives. According to Beer and Nohria (2000), 70% of change initiatives fail due to rushed and imposed changes. To understand what APQP can contribute to quality planning, knowledge must be disseminated throughout the company, something that Volvo GTO PTP in Skövde needs to consider when implementing APQP in their operations (Kim & Mauborgne, 2003). Currently, there are deficiencies in the transition between DVP and PSM projects, as the deliveries are not clearly specified. Thus, the APQP model is a methodology that can be applied to clarify the release of products and processes. APQP has been applied in projects involving new products; however, there is a lack of mapping of the competencies required for the execution of activities included in the model.

1.3 Purpose

The primary objective of this study is to evaluate the transition process from ISO 9001:2015 to IATF 16949:2016 specifically within the automotive industry. In order to accomplish this objective, a comprehensive mapping exercise will be undertaken to compare the existing project models, namely PSM and DVP, with the APQP model. The purpose of this comparison is to determine the feasibility of integrating the APQP model into the current project models or whether it is necessary to completely replace them.

Furthermore, the organization under investigation has initiated the implementation of APQP in a limited number of functions. Consequently, a gap analysis will be conducted to assess the level of involvement and familiarity of these functions with the APQP model. This analysis will help identify the existing gaps and shortcomings in terms of functions' understanding and utilization of the APQP model.

Ultimately, this study aims to present the research findings derived from interviews with relevant stakeholders and an extensive review of the pertinent literature. These findings will then be used to propose potential solutions for bridging the identified gaps in the context of the ISO 9001:2015 to IATF 16949:2016 transition within the automotive industry. The following research questions will be addressed to achieve the study's objectives:

- What is the current status of the DVP and PSM project models, which satisfy the requirements of ISO 9001:2015, and how do they compare to the desired APQP model that follows the IATF 16949:2016 standard?
- To what extent has the APQP methodology been implemented within the organization, and how widely is it used across different functions?
- How can gaps in organizational knowledge and implementation of the APQP model be bridged?

1.4 Delimitations

This study focuses exclusively on the Volvo GTO PTP in Skövde, primarily due to the significant organizational changes it is undergoing in relation to the development of new products and processes. Initially, other facilities within the Volvo Group were considered for this study. However, it was determined that these facilities have different production conditions compared to the Skövde site. The uniqueness of the Volvo GTO PTP in Skövde lies in its combined operations of foundry, machining, and assembly. Consequently, while this study primarily focuses on the Skövde site, it is intended to be applicable to other facilities within the Volvo Group and the broader manufacturing industries. It is important to note that the results may vary due to the differing conditions across these locations.

To provide a comprehensive understanding of Skövde's QMS, a gap analysis was conducted. This analysis aims to describe the current state of the QMS at Skövde and compare it with the IATF 16949:2016 quality assurance standard, which specifically applies to automotive industry

suppliers. The gap analysis was performed through qualitative interviews with individuals at the Skövde site who represent various organizational units affected by the new project model APQP. The selection of interview respondents was carried out in collaboration with Mattias Frisk, supervisor at Volvo GTO PTP in Skövde.

2 Business Overview

This section describes Volvo Groups' organization and operation together with current quality assurance work.

2.1 Volvo Group

Volvo Group consists of ten business units that operate across different segments to meet customer requirements and demands in the global market. These business units are Volvo Penta, Volvo Energy, Volvo Autonomous Solutions, Volvo Financial Service, Arquus, Volvo Trucks, Renault Trucks, Mack Trucks, Volvo Construction Equipment, and Volvo Buses. In addition, Volvo Group comprises three global organizations that focus on technology (Group Trucks Technology, GTT), manufacturing (Group Trucks Operations, GTO), and purchasing (Group Trucks Purchasing, GTP) (Volvo Group, n.d.). This report aims to investigate Volvo GTO PTP located in Skövde, Sweden, which primarily deals with foundry, machining, and assembly. Volvo GTO PTP supplies engines and engine components to production facilities of the Volvo Group (Volvo Skövde, n.d.). Figure 2.1 illustrates the organizational structure of the Skövde plant, and the gray area marks this report's division.

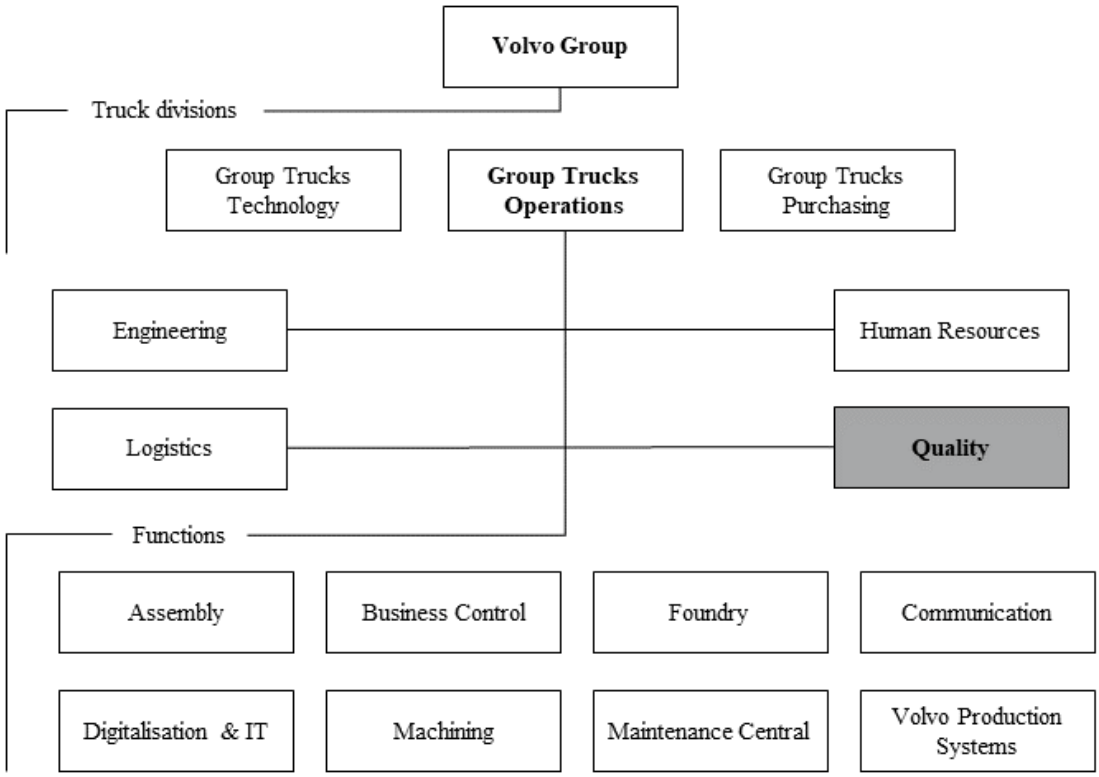

Figure 2.1. An organizational chart of the Volvo Group Trucks Operations in Skövde (adapted from Johansson., 2023)

2.2 Total Quality Management at Volvo GTO PTP

Volvo GTO PTP works with quality as a measurement to evaluate performance in meeting customer requirements and surpassing their expectations. In order to create a culture of continuous improvement that enhances organizational performance and success, employees use the "right for me" approach to take ownership and contribute to this process (Lundstedt, 2020). To enhance customer satisfaction, it is crucial to quality-assure the product and process development. As a result, Volvo GTO PTP utilizes two project models: DVP for product development and the PSM for process development, as shown in figure 2.2 with corresponding work packages. However, the organization has identified a lack of a natural transition between these models, particularly when projects shift focus from product construction to process development. For more detailed information on the project models, refer to section *3 Literature Review.*

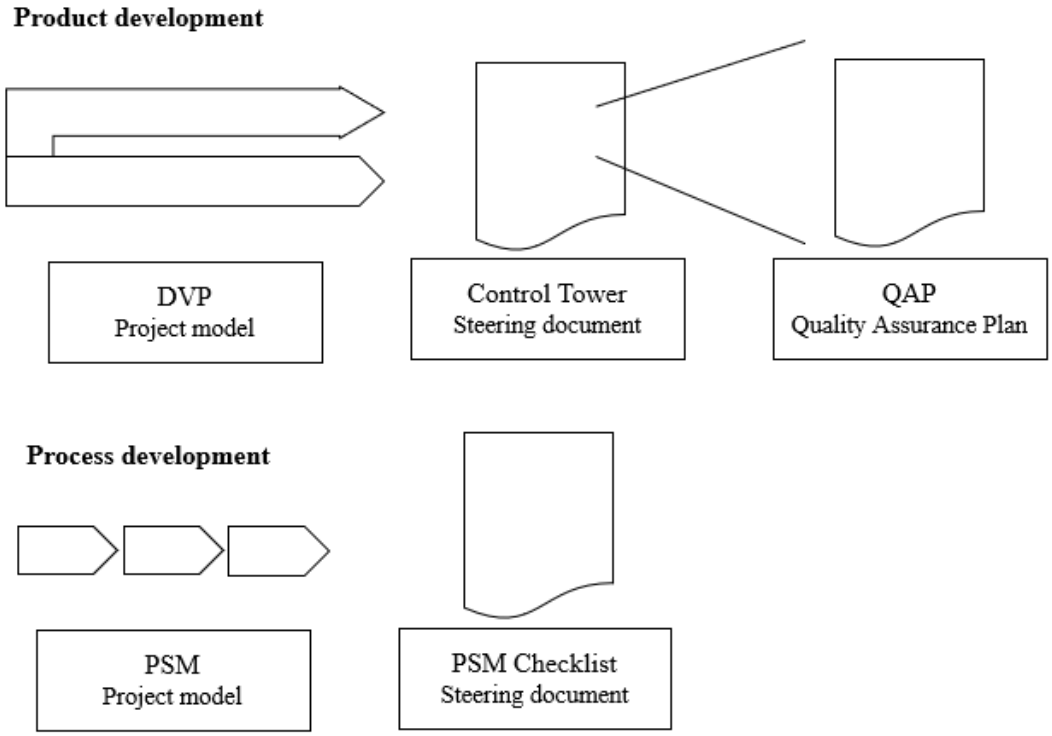

Figure 2.2. Visualization of the separate project models that is used to release a product or process.

Volvo GTO PTP's objective is to establish one project model that is applicable to both project and process development (M. Frisk, personal communication, January 17, 2023). The organization have adapted a new project model that is derived from the APQP methodology, which supports the organization to validate product and process development together. Rousch et al. (2008) suggest that requirements outlined in IATF 16949:2016 can be obtained by following the APQP method. The intended project model aims to adopt a structured approach consisting of four levels, as illustrated in figure 2.3 (Frisk & Sandström, 2023).

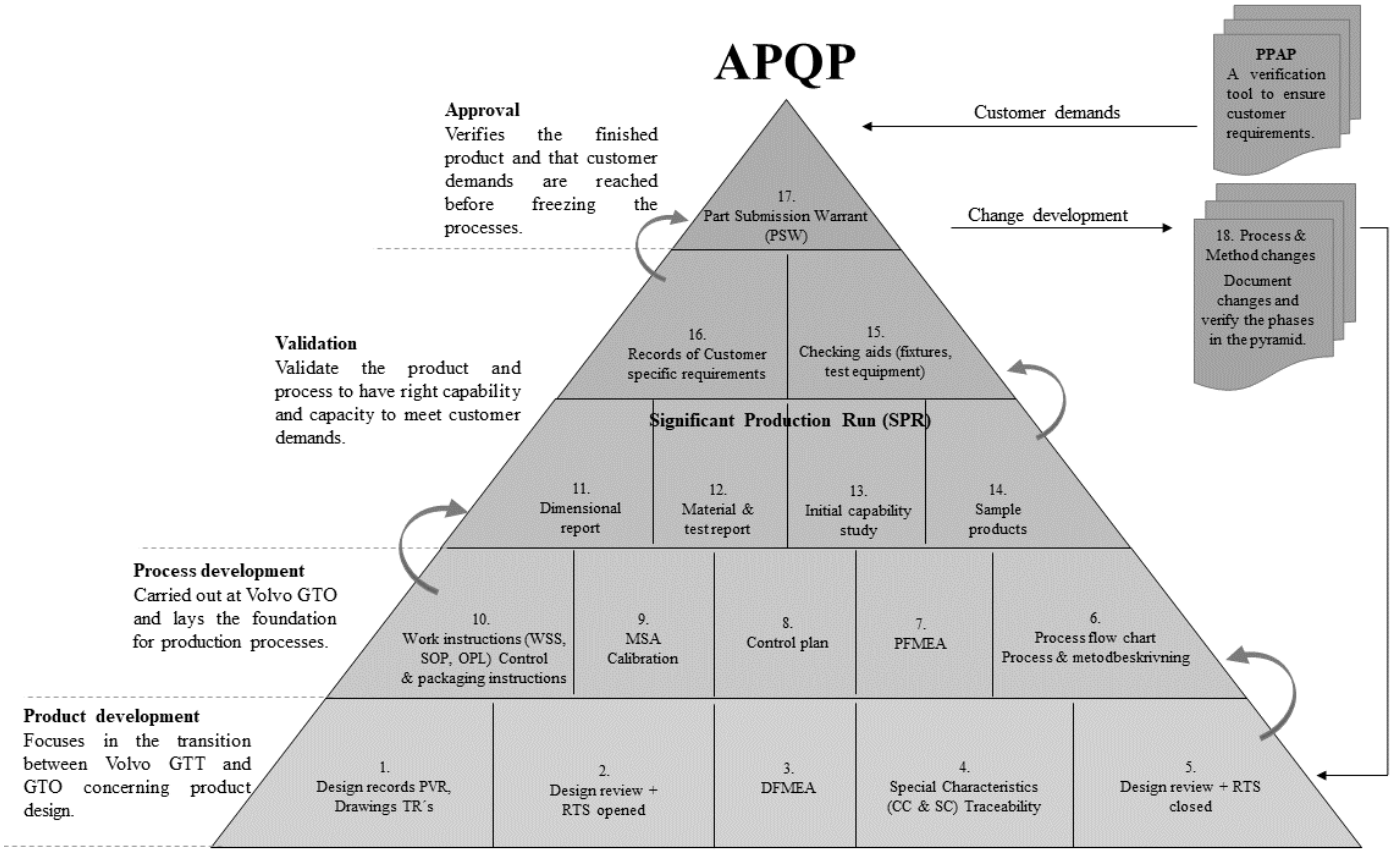

Figure 2.3. Presents a visualized structure for the future project model APQP that Volvo GTO PTP in Skövde adapted.

3 Theoretical Framework

This report is based on scientific literature concerning the following areas: Quality Management Systems, Quality standards, Project models, and Change Management.

3.1 Quality Management Systems

Due to the rapid shift in demand for sustainable solutions in the market, organizations need to adopt a proactive approach that ensures defects do not occur rather than a reactive approach that solves issues as they arise. A proactive approach is necessary to reduce waste when resolving quality issues. To create a proactive approach, organizations should consider how the supply chain is constructed for producing, developing, and selling products (Illés et al., 2017, chapter 2.2). Quality control creates the conditions for establishing processes that achieve the required quality (Tonnquist, 2021). According to Bergman and Klefsjö (2020), quality development can be divided into four phases at different stages of production, as shown in figure 3.1.

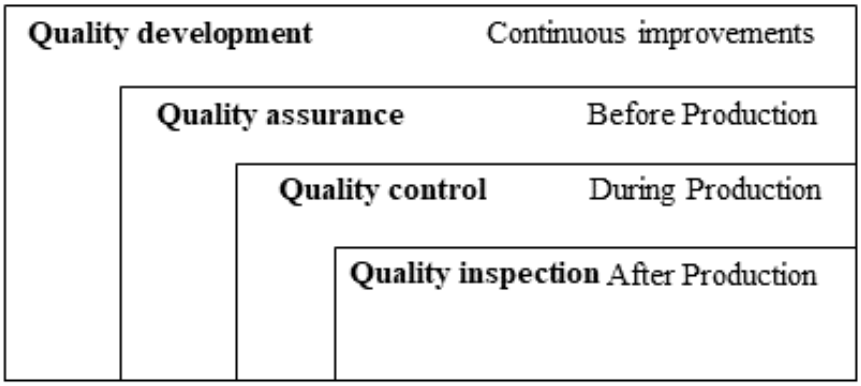

Figure 3.1. Illustration of the four stages of quality development, adapted from Bergman and Klefsjö (2020).

A process is a combination of activities with at least one supplier and customer that is repeated over time and adds value to the customers (Bergman & Klefsjö, 2020; Tonnquist, 2021). To achieve the target quality, a QMS is a critical component of an organization's management system. QMS focuses on achieving the desired quality and continuous improvements within an organization (Bergman & Klefsjö, 2020). QMS has evolved from being perceived as quality assurance to a total quality management approach in organizations (Garcia et al., 2017). This change has occurred throughout the entire organization, and the quality standards now affect the whole organization (van der Wiele et al., 2005). Quality standards, such as ISO, can now be regarded as a requirement for competitiveness in the international market (Gutiérrez et al., 2010).

From a business perspective, Mokhtar and Muda (2012) explain that having a certified QMS positively impacts business performance, such as increased customer satisfaction and reduced customer complaints, as stated in Casadesús and de Castro's (2005) study. Furthermore, QMS has positively impacted the development, manufacturing, installation, maintenance, and project management of companies in the automotive industry (Franceshine et al., 2011). McTeer and Dale (1996) suggest that revenue growth is a result of QMS implementation. However, if a standard is used only as a marketing tool, its effect will be reduced (Sampaio et al., 2009).

Aggelogiannopoulos et al. (2007) found that QMS improves organizations in important areas such as customer satisfaction and defect reduction. Furthermore, if the organization understands the benefits, it will create motivation for quality improvement. However, as concluded by Wardhani et al. (2009), the implementation of a QMS is not an easy task. Top management commitment is the primary requirement for successful QMS implementation, and the authors found a need for diffused quality management. Piskar and Dolinsek (2006) also point out that managers must be perceived as role models for employees to trust and follow them. The model also needs to be adapted to the organization. Furthemore, according to Illés et al. (2017, chapter 2.2), organizations must adapt and continuously improve the QMS to meet the customer's and the organization's needs.

3.2 ISO 9001:2015

An ISO standard can be described as a set of guidelines that outline an effective way to carry out a particular task or process (ISO, n.d). These standards are developed by experts from various organizations with expertise in different subjects. The ISO 9001:2015 quality standard is applicable to any organizations across different fields, and as of 2021, over 1.4 million sites had been certified with this standard, which is more than twice the number of sites certified with the ISO 14001:2015 standard (ISO, 2023). The purpose of the ISO 9001:2015 standard is to build trust in corporate products and services and to provide a framework for QMS. The requirements are general and can be applied to different organizations, regardless of the industry, product or service offered. The terminologies used in the standard are not mandatory, and organizations can use other appropriate terms that suit their organizational structure (Bergman & Klefsjö, 2020). The ISO 9001:2015 standard is regularly revised to ensure that it keeps up with market developments and industry demands (Fahmi et al., 2021).

The ISO 9001:2015 standard differs from its predecessor, the ISO 9001:2008, in several ways, such as changes in the standard's structure, terminologies, documentation requirements, management principles, risk-based approach, and understanding of stakeholders' needs and expectations (Bergman & Klefsjö, 2020, p.535). A study conducted by Afriyuddin et al. (2019) on the impact of upgrading from ISO 9001:2008 to ISO 9001:2015 at an automotive company revealed a decrease in production rejects from 0.75% to 0.30%, with an expected increase in productivity. According to Fahimi et al. (2021), the standard also affects QMS and correlates with manufacturing performance.

The quality standard, ISO 9001:2015, follows seven established quality management principles that ensure organizations work towards customer satisfaction and facilitate the implementation of QMS. The seven principles are customer focus, leadership, engagement of people, process approach, improvement, evidence-based decision-making, and relationship management (Ellis, 2019; ISO, 2019). Furthermore, ISO 9001:2015 standard consists of ten clauses that focus on various aspects that contribute to developing a QMS (ISO, 2019). One of these clauses emphasizes the need to apply a process approach when developing, implementing, and improving a QMS to increase customer satisfaction and meet customer demands. Furthermore, understanding the integration and management of processes can contribute to effectiveness and efficiency in an organization. Figure 3.2 provides an overview of the process approach for ISO 9001:2015, where there are checkpoints between different stages that are crucial for controlling potential risks and ensuring control over a single process containing suppliers, input, processes, output, and receivers of output (Bergman & Klefsjö, 2020; ISO, 2015). Applying the process approach can generate opportunities for a QMS, such as an awareness of demands, taking value-creating processes into account, targeting process performance, and evaluating data for process improvements (ISO, 2015).

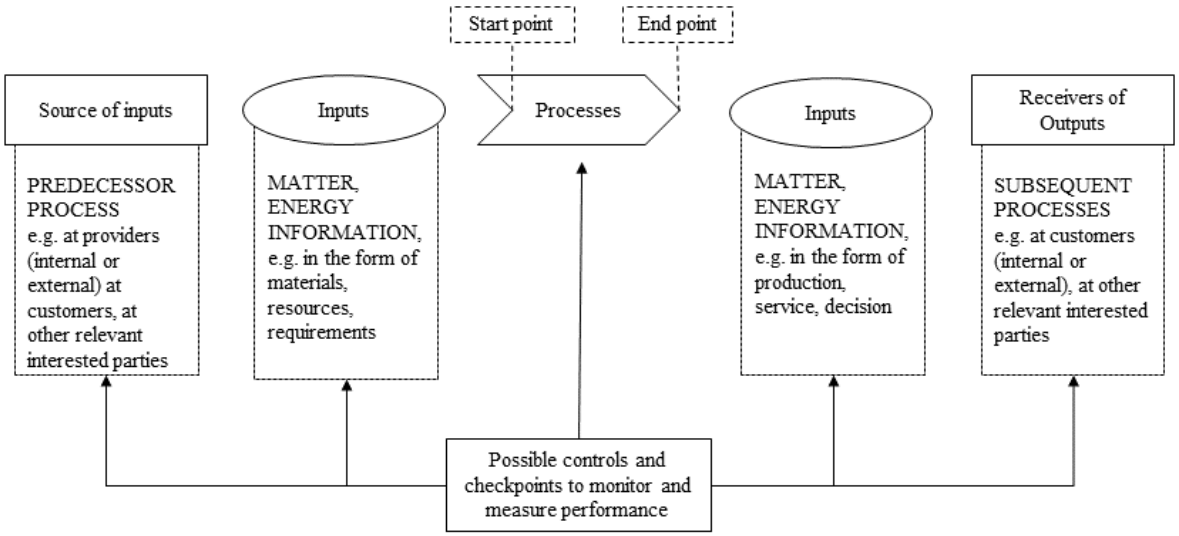

Figure 3.2. Presents a model that describes the elements of a single process, adapted from ISO (2015).

Clauses 4 to 10 of ISO 9001:2015 are associated with risk-based management, and are adapted to align with the PDCA cycle (Plan, Do, Check, Act), which is applied in the QMS, as presented in figure 3.3. The PDCA cycle is a methodology that manages processes and systems from a risk-based perspective to mitigate unwanted outcomes (ISO, 2015).

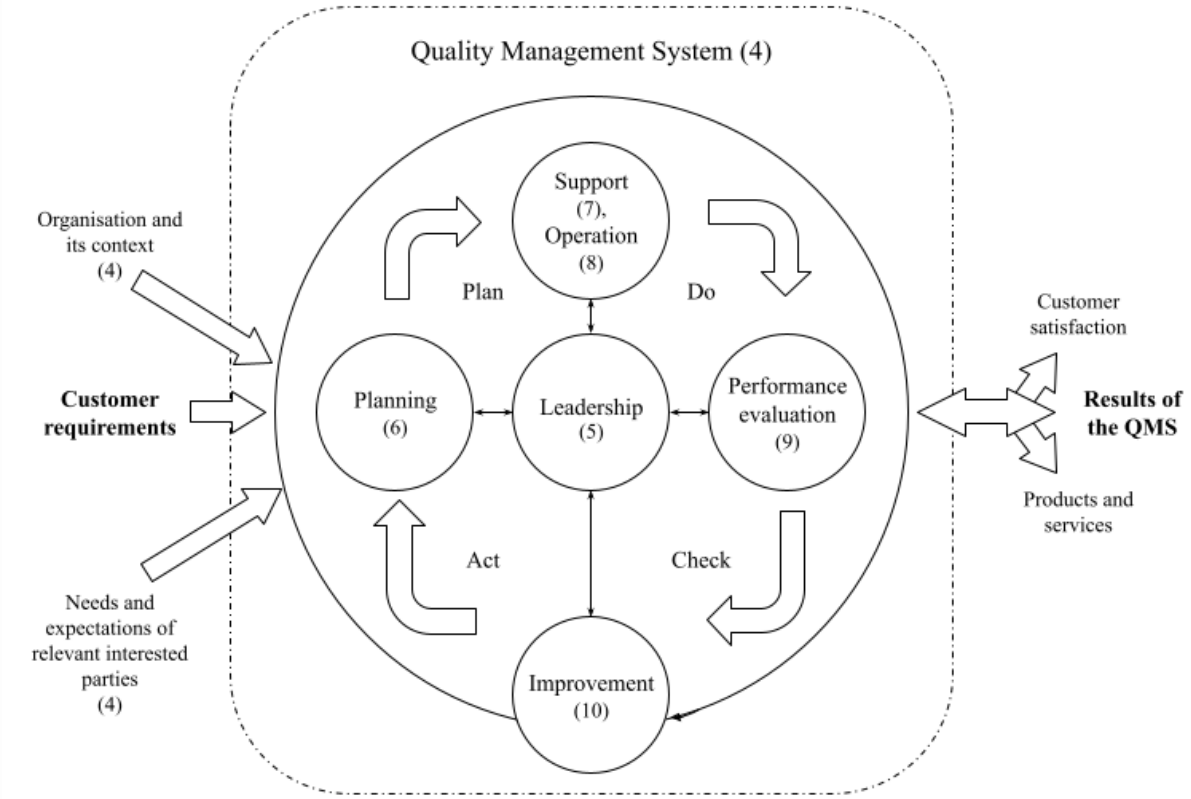

Figure 3.3. Presents the correlation between the international standard, including clauses, and the PDCA cycle, adapted from ISO (2015).

As per clause 4, the input is related to the organization's ability to address internal and external issues that can impact strategic decisions. Essential approaches to include are stakeholder requirements, process development, and accountability. Clause 5 deals with management's responsibility and commitment to the management systems to ensure that the organization adheres to standard requirements and works towards continuous improvement. Clause 6 is centered around planning to ensure the availability of resources when required and assess risks that may arise during projects. Additionally, clause 7 identifies key stakeholders who must provide resources to establish, implement, maintain, and enhance the QMS. Clause 8 focuses on the organization's responsibility to plan and control processes that meet the demands for products and processes. Clause 9 specifies what must be measured, monitored, and analyzed, ensuring that the organization complies with system requirements. Finally, clause 10 addresses the possibility of making improvements to meet customer requirements and enhance customer satisfaction, which is the output of the PDCA cycle (Bergman & Klefsjö, 2020; ISO, 2015).

3.3 IATF 16949:2016

The manufacturing industry has faced increasing sustainability challenges, which have impacted the strategic direction of organizations. To address these challenges, flexible solutions and continuous innovation are essential (Benabdellah et al., 2020). Laskurain-Iturbe et al. (2021) suggest that the quality management standard IATF 16949:2016 offers more flexibility than other quality management standards in areas such as market, customer service,

operational performance, employees, and technology. IATF 16949:2016 is derived from the technical specification ISO/TS 16949:1999, which was developed by the International Automotive Task Force (IATF) (IATF, 2016). According to Bergman and Klefsjö (2020), IATF was established in 1996 by representatives from the automotive industry. In 2016, the latest version of the standard was created to focus more on risk management, steering of suppliers, supplier evaluation, product safety, and supply of competence. The standard was audited to meet the increased quality requirements of the automotive industry (IATF, 2022). The primary objective was to create a global standard and harmonized certification system for the automotive industry supply chains (IATF, 2016).

The changes made in IATF 16949:2016 were driven by the complaints of the automotive industry about the implementation of ISO 9001:2015, which, in their opinion, did not adequately reflect the required level of certified organizations (Kymal, 2006). A survey of OEMs found that 90% of 9300 IATF 16949:2016 certified companies met customers' requirements, while only 73% of 1500 ISO-certified companies met customer requirements (IATF, 2022). Ruswanto and Saroso (2018) explain that IATF 16949:2016 builds upon ISO 9001:2015 by adding Customer Specific Requirement and new IATF clauses, which are illustrated in figure 3.4. The primary difference between ISO 9001:2015 and IATF 16949:2016 is that ISO 9001:2015 focuses on customer satisfaction, while IATF 16949:2016 focuses on customer requirements and the reduction of waste throughout the supply chain (DNV, n.d; IATF, 2022).

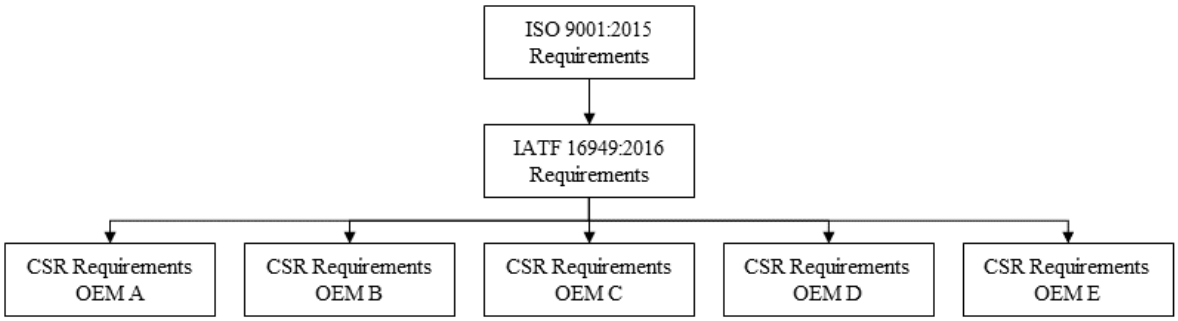

Figure 3.4. Illustration of the structure of IATF 16949:2016, adapted from Garcia et al. (2017).

Furthermore, IATF 16949:2016 is used to create the prerequisite for profitability and customer relations through flawless deliveries, reduced defects cost, and continuous improvements (Ellis, 2019). Hence correlation to the target of IATF 16949:2016 emphasizes the reduction of waste throughout the supply chain, leading to profitability and customer relations through flawless deliveries, reduced defects cost, and continuous improvements (IATF, 2016).

3.4 Process Development

In every organization, uncertainties and risks are present, which Tonnquist (2021) argues are dependent on project development and the involvement of individuals with no previous collaboration in projects. A risk is characterized by an unpredictable activity with unpredictable consequences that makes it difficult to foresee the outcome. On the other hand, uncertainty is

related to a known activity that could have different results depending on internal and external factors. In project management and risk management, Ahlemann et al. (2013) suggest that problems arise due to non-acceptance in practice, limited effectiveness, and ambiguous application scenarios. Thus, proactive measures are essential to reduce project uncertainties and risks, following three steps: identification, analysis, and evaluation of strategies. Implementing these steps can achieve the project goal more efficiently, with fewer unforeseen events (Tonnquist, 2021).

Bergman and Klefsjö (2020, p. 529) define a project as a "unique process, consisting of a number of coordinated and controlled activities with start and end dates, initiated to achieve a goal that meets specific requirements, including constraints on time, cost, and resources," which is similar to Volvo GTO PTP's definition of PSM (Ornelid, 2023). Therefore, a project model is essential because it provides an organization with a shared methodology and language and a common decision-making process in projects. Additionally, project models play a crucial role in the project process, responsibility and authority, communication of results and costs, and provide an overview to prioritize activities between different projects (Ornelid, 2023; Tonnquist, 2021). The PSM's advantage is that it is generic and can work within all types of projects regardless of industry and content. Figure 3.5 depicts a generic project model flow chart consisting of phases (activities in a project), gates (decision points) from an idea to a complete project, and the project management structure. Furthermore, stakeholders, such as an organization, a group, or an individual, should be involved throughout a project because they can influence the result and be affected by it (Ornelid, 2023).

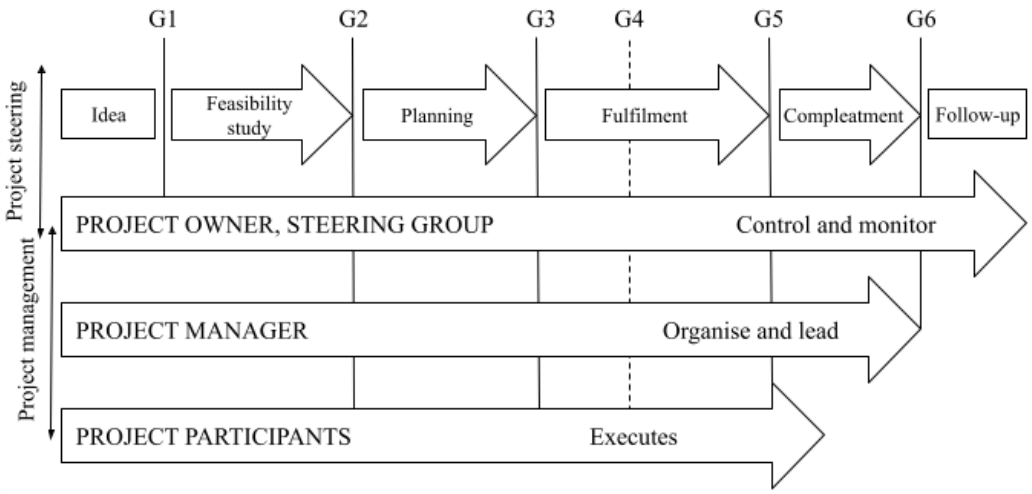

Figure 3.5. The structure of a general project model containing roles in a project organization, adapted from Ornelid (2023) and Tonnquist (2021).

Risk management has become a significant aspect of project organizations since the 2008 financial crisis due to its negative impact on business opportunities, according to Rabechini Junior and Monteiro de Carvalho (2013). Their study on risk management's influence on project performance in the industrial sector in Brazilian companies demonstrated a significant correlation between risk management and project success, such as understanding and

responsibility for uncertainties, application of processes, methods and tools, and organizational awareness. From a strategic management perspective, it is recommended to have a specialist solely responsible for risk management as it increases the chances of achieving project success almost four times. Tonnquist (2021) defines a risk event as an activity that negatively impacts a project. Therefore, risk management is crucial for successful projects. A four-step method can be conducted, with the first three: risk identification, risk action plan, and risk evaluation, controlled before project completion. In contrast, risk management occurs during the project. The author advocates for allocating 15-25% of the project time to handle risks during the project period. Kim (2016) confirmed that project planning is essential to maximize project performance, and the performance can be affected at an early stage of the process development. This strategy is called front-loading and generates faster development (Dolfsma et al., 2022; Thomke & Fujimoto, 2000).

3.5 Product Development

Product developers have faced increased challenges since society is continuously moving forward, and the future is uncertain and less predictable (Bhuiyan, 2011; Cooper, 2019). Studies by Cooper (2017) and Cooper et al. (2004) indicate that around 40% of product launches fail to achieve financial objectives. Failures are often attributed to poor market research, inadequate product testing, and suboptimal product launch strategies (Cooper, 2019). Consequently, developing product systems requires careful consideration of the process, including project planning and control, such as budget, resources, timeframe, and risk management.

The adoption of a product development framework promotes knowledge management, which is a critical element in Volvo GTO PTP's product development model DVP, aimed at preserving knowledge and experience across projects (A. Högman, personal communication, Mars 10, 2023). Browning et al. (2006) highlights that knowledge management is essential in product development, as it facilitates the sharing of experiences, skills, and expertise among team members. Bergman and Klefsjö (2020) suggest that the stage-gate model, which Cooper (2017) developed, is a typical product development model, as shown in figure 3.6. The model's gating processes may seem rigid and formal, inhibiting proactive changes in manufacturing industries' development processes (Cooper & Sommer, 2018).

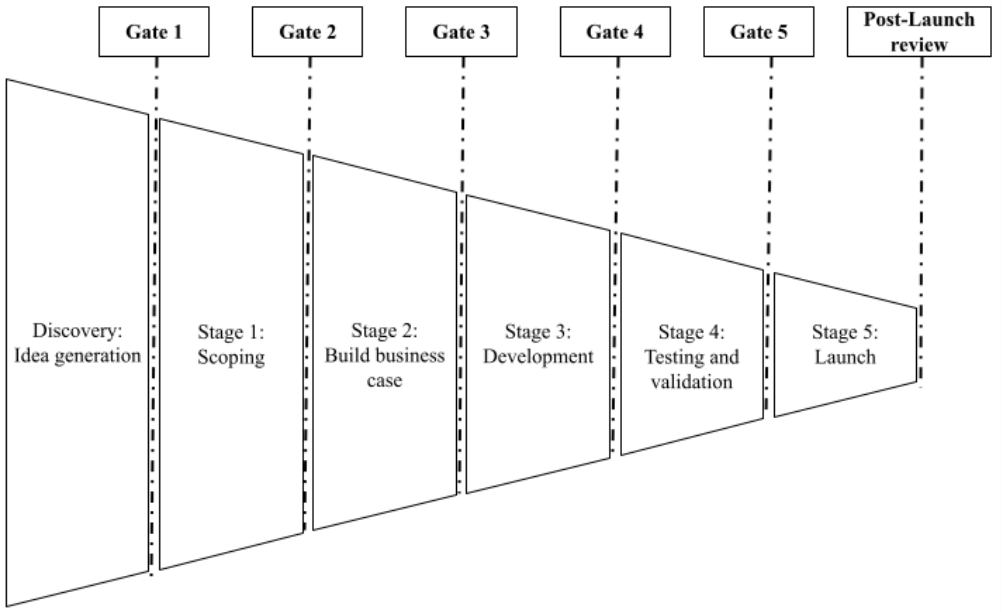

Figure 3.6. An adapted model of a stage-gate process based on Cooper's (2017) model.

Manufacturers in North America and Europe have integrated principles from agile development processes into their stage-gate model (Bergman & Klefsjö, 2020). This approach provides agile work packages and close customer connections with stages and gates where teams can present results and terminate the project if necessary. The benefits of this method include a clear structure, process control, time-effectiveness, resilience, and productivity. Additionally, agile thinking promotes short intervals between follow-ups, encouraging teams to improve their work processes continuously. This approach is best applied after the streamlined stage gate, and management must consider that implementing new methods may take time to adjust (Bergman & Klefsjö, 2020). The Cooper and Sommer (2018) case study recommends starting with a pilot project where senior management is responsible for analyzing the output. Moreover, the study showed that companies should provide extensive training for teams by experts and support from external resources to ensure a smooth transition to the agile stage-gate model. Finally, management must communicate risks and challenges clearly throughout the implementation phase to ensure its success, with the agile stage-gate model being aligned with the organization's structure.

3.6 Advanced Product Quality Planning

APQP is an adaptable approach that aims to enhance productivity while achieving high potential quality improvement to product development (Mittal et al., 2012). As noted by Rousch et al. (2008), implementing product quality planning can provide numerous benefits, including direct resources for customer satisfaction, early identification of changes, avoidance of late changes, and delivery of high-quality products at a reduced cost. Additionally, APQP can support decision-making processes based on user preferences (Ivert & Jonsson, 2010).

To fully obtain the benefits of APQP, Rousch et al. (2008) suggest that tools and analytical techniques should be employed as early as possible during the product quality planning cycle.

Figure 3.7 demonstrates how the five phases of APQP are linked to the PDCA cycle (Rousch et al., 2008).

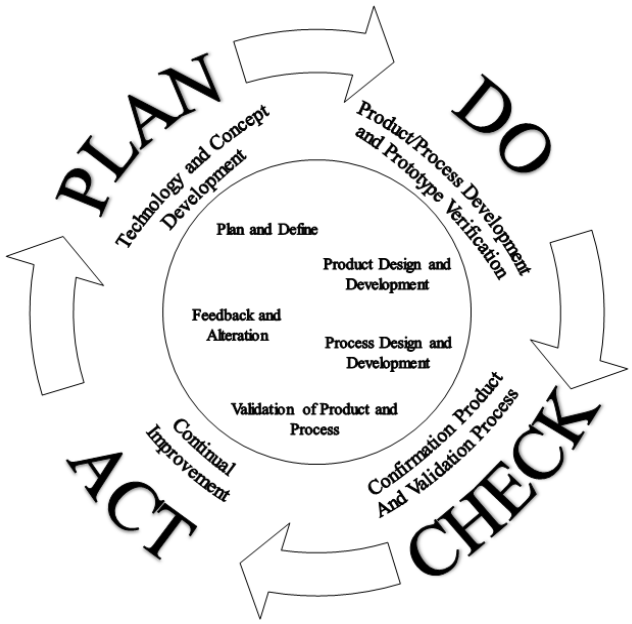

Figure 3.7. APQP five phases correlation to PDCA, adapted from Rousch et al. (2008).

Plan and define describes the connection between customer needs and planning a quality system.

Product design and development where all design characteristics are refined to an almost final state.

Process design and development handles the major parts of developing a manufacturing system and the control plan that was input from phase two.

Validation of product and process consists of a significant production run to evaluate the process.

Feedback and alteration, where the product can be evaluated and altered.

3.7 Change Management

Organizations have recognized that they must adapt to change to survive in the market. However, effecting change is challenging, with approximately 70% of change initiatives proving unsuccessful, largely due to rushed and coerced implementations (Beer & Nohria, 2000). Change does not happen through the way of thinking, instead, it is about changing behaviors. As such, employees must adapt to new behaviors, a process that can prove challenging due to the comfort and familiarity of established working arrangements (Garvin & Roberto, 2005). Although Kim and Mauborgne (2003) argue that once a new way of thinking becomes widely accepted, transformation will spread like a wildfire. Meyerson (2001) suggests that organizational change can occur either through drastic or evolutionary changes. The former approach involves changes that are forced onto an organization or mandated by top management due to innovations, resource assets, or changes in administrative, regulatory, competitive, or government requirements.

The latter approach, in contrast, entails profound, long-term, transformational change through gradual and decentralized modifications. Drastic changes can occur quickly and can be disruptive to an organization's established culture (Orlikowski, 1993). Two strategies that correspond with drastic and evolutionary changes are Theory E and Theory O, which Beer and Nohria (2000) discuss in their article. Theory E is a "hard" approach that focuses on change strategies based on economic value, such as incentives, downsizing, and restructuring. In the United States, Theory E is more common due to financial considerations, while Asian and

European businesses tend to adopt Theory O more frequently. Theory O, on the other hand, takes a "soft" approach to organizational change and considers culture and human capability to build emotional commitment. Organizations that combine both theories are more likely to increase profitability and productivity, leading to long term competitiveness.

Forced change can negatively impact outcomes and can be time-consuming, whereas transformational change is a process that many managers must understand to achieve a successful change initiative (Kotter, 2007). The challenge in managing change lies in determining what influences change initiatives, according to Sirkin et al. (2005). It is common for companies to focus on the "soft" side of change, such as leadership, motivation, and culture. While these factors are essential for success, they are insufficient in isolation for transformation projects. Research has shown that two out of three transformation programs fail due to an overemphasis on "soft" change factors. Therefore, "hard" aspects are also important to consider, as organizations can measure direct and indirect impact on change, hard aspects are easy to communicate, and an organization can influence hard elements immediately. By following the DICE method, the chances of achieving project success are significantly increased. Figure 3.8 provides an explanation of the method.

D	**Duration** Evaluation of milestones should occur often to identify and handle potential problems at an early stage.
I	**Integrity** The project team's ability to complete change projects on time and successfully.
C	**Commitment** Involve and motivate managers and employees that are affected by the change to make the transformation successful.
E	**Effort** The increased workload for employees must be considered when changing processes.

Figure 3.8. Explanation of the DICE method, adapted from Sirkin et al. (2005).

To achieve successful change management, Beer et al. (1993) emphasizes the importance of clearly defined business problems that necessitate commitment, coordination, and competence. According to Kegan and Lahey (2001), resistance to change is not primarily a result of individual attitudes but is rooted in competing commitments that divert people's energy away from change initiatives and make them immune to change due to their personal agendas. Resistance can manifest as defiance to change and can have detrimental effects on both employees and the overall performance of the company.

4 Research Methodology

The following section presents the methodology used in this report and a discussion of reliability and validity.

4.1 Scientific Approach

In this report, two scientific approaches, deductive and inductive, are discussed in the context of a research project aimed at implementing a new way of managing the standard IATF 16949:2016. A deductive approach involves testing an existing hypothesis and requires extensive structure in quantitative data collection (David & Sutton, 2011). Deductive approach typically describes relationships between variables. In contrast, an inductive approach is used to create an understanding of a chosen research area and its attachment to human aspects (Saunders et al., 2009). Inductive approach is more flexible, allowing for changes in the research's development.

This report uses an inductive approach that is appropriate due to the research project focusing on implementing a new way of working. This approach correlates with qualitative methods, which create a more in-depth analysis and an overall picture of the researched subject (Saunders et al., 2009). Qualitative data collection methods, such as interviews, provide opportunities for flexible discussions and follow-up questions, allowing for a more comprehensive understanding of the research subject.

Moreover, the limited knowledge of the research subject makes it challenging to create a hypothesis for a deductive approach. A quantitative approach would involve systematically collecting empirical and quantifiable data, which is then compiled through statistical tools to analyze existing hypotheses (Saunders et al., 2009). However, in this report, a qualitative approach is more appropriate because it aims to present not only the gap but also how the gap can be bridged. A quantitative approach would have found the gap but would have limited the information on how to overcome the challenges.

4.2 Research Approach

Opie (2019) explains diverse research approaches, including case studies, action research, and experiments, that researchers can adopt depending on the nature and timeline of their research projects. Yin's (2009) examination of five common research approaches that can be used depending on the type of project is comparable to Opie's (2019) study. These five approaches include experiments, surveys, archival analysis, histories, and case studies. Yin (2009, p. 8) recommends considering three factors when choosing a research approach, namely: (1) the type of research question, (2) the extent of control the investigator has over actual behavioral events, and (3) the degree of focus on contemporary as opposed to historical events. Figure 4.1

provides an evaluation framework to assist in selecting the appropriate approach for a given research project.

METHOD	(1) Form of research question	(2) Requires control of behavioral events?	(3) Focuses on contemporary events?
Experiment	how, why?	yes	yes
Survey	who, what, where, how many, how much?	no	yes
Archival analysis	who, what, where, how many, how much?	no	yes/no
History	how, why?	no	no
Case study	how, why?	no	yes

Figure 4.1. Presents different research methods to evaluate for projects, adapted from Yin (2009).

As illustrated in figure 4.1, a case study is the most appropriate research approach for this project. The research questions adopt an inductive approach to provide comprehensive information on the researched subject, thereby making a case study suitable. Additionally, qualitative data collection through interviews lacks control over behavioral events such as respondents' responses, further supporting the use of a case study. Lastly, case studies predominantly focus on contemporary events, which aligns with this project's evaluation of IATF 16949:2016 as a new event for the organization.

4.3 Data Collection and Analysis

The process of data collection began by reviewing internal documents obtained from Volvo GTO PTP's intranet and conducting a literature review. This was done to establish a foundation for subsequent interviews, which were analyzed using a thematic method. This approach helped to develop a clearer understanding of Volvo's current work on quality preparation. The process of data collection and analysis is presented in figure 4.2 and further elaborated in the subsequent sections. The findings from the interviews were then used to perform a comprehensive gap analysis that combined theoretical and practical aspects of current project models with the correlation to APQP. Additionally, the respondents' experiences with APQP were evaluated. Based on the results of the study, a recommendation has been proposed to address the identified gap, which can be found in section 7 of this report.

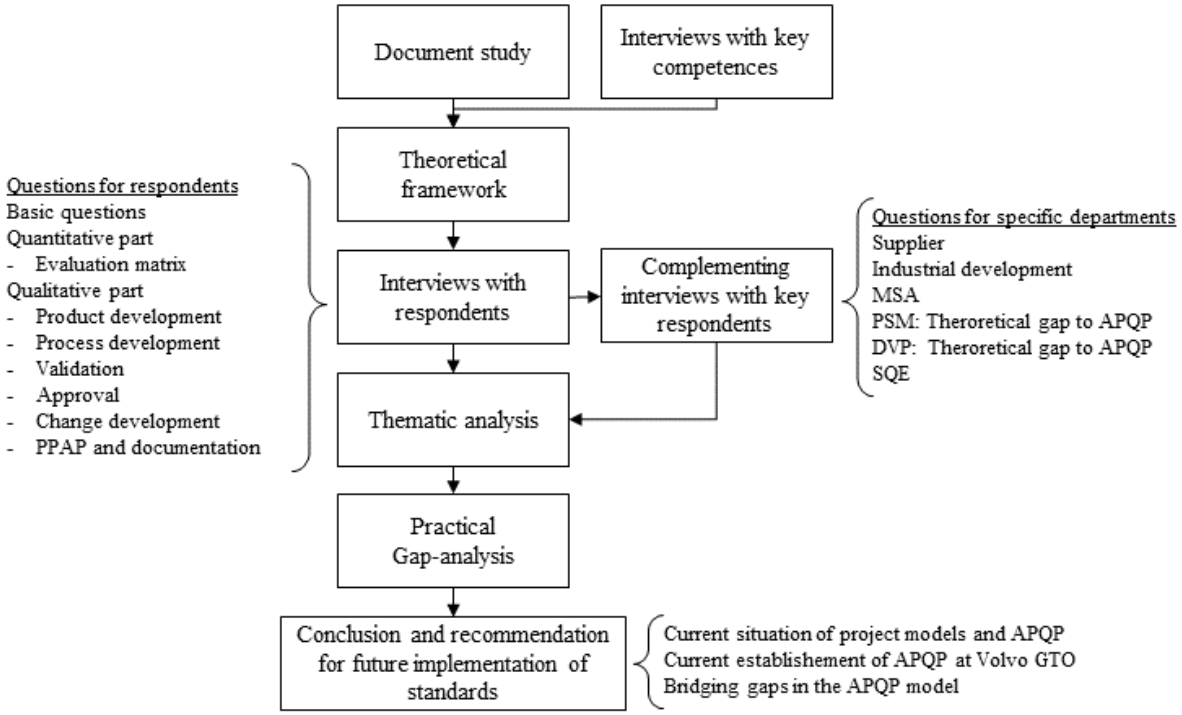

Figure 4.2. Presents an overview of acquiring data and the process of analyzing.

4.3.1 Document study

The documents were accessed through the organization's intranet and served as the basis for developing the interview guide and conducting the gap analysis. The methodology used in the document analysis followed a similar work arrangement as that employed by Ranängen and Zobel (2014), whereby the information was systematically gathered and categorized according to the areas of interest, as outlined in table 4.1. It is important to note that due to confidentiality concerns, the reviewed documents will not be disclosed in the study.

Table 4.1. Audited steering document from the Volvo intranet.

Document	**Area**	**Update**
Advanced Product Quality Planning (APQP) and Control Plan	APQP	2008
DVP Handbook	DVP	2022
DVP project handbook	DVP	2020
Grundutbildning i IATF 16949 och ISO 9001: Hur kan vi bli en bättre leverantör med hjälp av IATF 16949	IATF	2019
IATF 16949, Quality management system requirements for automotive production and relevant service parts organisations.	IATF	2016
ISO 9001 - Quality management systems - Requirements	ISO 9001	2015
Project Steering Model: For Project Team Members	PSM	2023
Volvo Group Quality Policy	Quality	2020

4.3.2 Theoretical Framework

The theoretical framework was conducted in two parts: a literature search to find relevant material and an in-depth analysis of the content. To structure the content of the literature search, the division recommended by David and Sutton (2011) was followed, which involved searching for material related to the subject area. The PRISMA 2020 method was also used as a guideline to ensure a transparent and accurate reporting of findings, thus improving the reliability and validity of the report. Additionally, PRISMA 2020 was utilized in this report to select the articles equally among the authors, which helped evaluate and improve systematic review. Moreover, it was also used to assess the trustworthiness of published journals (Page et al., 2021; Sarkis-Onofre et al., 2021). In addition to the PRISMA 2020 method, articles that focused on the production industry in general and automotive industry specifically were prioritized because of the relevance to the research area. The search was based on keywords focusing on following areas Quality Management Systems, Quality Standards, Project Models and Change Management. Furthermore, the selection was based on how the abstract of the articles correlates to the research questions of this study. Additionally, the number of citations were considered.

The literature search was conducted using several databases, including Google Scholar, LTU library, and Scopus, to find peer-reviewed scientific articles and literature relevant to the report. To expand the literature search, the snowball method was used to review reference lists from previously selected articles, ensuring the credibility and relevance of the reports (David and Sutton. 2011).

4.3.3 Interviews

This report employs a qualitative research approach that involves the use of interviews as a data collection method. The questions developed for the interviews were based on a literature review, and Appendix A provides a description of the interview structure and the various elements that the questions added to the study. The interviews utilized a semi-structured approach, which, according to David and Sutton (2011), provided the flexibility to modify questions based on the interviewee's responses. This enabled the asking of follow-up questions that were relevant to the answers provided. Fifteen respondents from different departments in the organization were interviewed to obtain different perspectives on how competence development is carried out in the organization (table 4.2). However, R13's interview evolved into a compliance interview because of other key competencies that did not correlate to the gap analysis. The length of the interviews varied between 30 to 80 minutes depending on the respondent's position, knowledge and involvement in the APQP model.

Table 4.2. Presents the interviewed respondents, the department, the date and duration of the interview.

Respondent	Department	Date	Duration
R1	Steering group	2023-03-14	43 min
R2	Machining	2023-03-15	42 min
R3	Quality	2023-03-16	42 min
R4	Foundry	2023-03-16	40 min
R5	Machining	2023-03-20	42 min
R6	Assembly	2023-03-20	44 min
R7	Assembly	2023-03-21	38 min
R8	Steering group	2023-03-22	60 min
R9	Machining	2023-03-23	35 min
R10	Steering group	2023-03-23	70 min
R11	Machining	2023-03-24	35 min
R12	Assembly	2023-03-27	67 min
R13	Development	2023-03-13	80 min
R14	Foundry	2023-04-06	45 min
R15	Foundry	2023-04-06	45 min

The process of finding respondents was challenging to randomize since it required a relevant selection with experience and correlation with project models. Hence, an inductive approach was used, where a respondent's network gave access to further interviews. In this study, the supervisor's network at Volvo GTO PTP was used as a starting point. Unstandardized interviews were conducted to allow respondents to provide open-ended answers, expressing their opinions. According to Morgan and Harmon (2001) and Paradis et al. (2016), this type of arrangement is recommended, although it requires more effort to analyze. Therefore, in addition to the open-ended interview, an evaluation matrix was developed based on the APQP method to quantify the existing organizational gap (Appendix B). The respondents were presented with the evaluation matrix, enabling them to evaluate themselves and lay the foundation for discussion and follow-up questions.

Moreover, compliance interviews were conducted to collect information about specific topics that the authors needed a deeper understanding of. The respondents have been labeled CX and are listed in table 4.3 together with the topic. C1 was a visit to a supplier to Volvo GTO PTP. The visit gave understanding of the opportunity and challenges with implementing IATF 16949:2016 which the supplier is certified with. The compliance interviews with C5, C6, and C8 laid the foundation for a theoretical comparison between the current project models, PSM and DVP, and APQP.

Table 4.3. The compliance interviews with respondents, the topic, the date and duration of the interview.

Compliance	Topic	Date	Duration
C1	Supplier	2023-03-13	5 hours
C2	Industrial development	2023-03-30	80 min
C3	MSA	2023-03-31	60 min
C4	MSA	2023-03-31	60 min
C5	PSM	2023-04-05	30 min
C6	PSM	2023-04-05	30 min
C7	SQE	2023-04-11	35 min
C8	DVP	2023-04-12	30 min

A gap analysis tool was developed to quantify and summarize the gap, and this tool is explained in Appendix C, inspired by the AIAG (AIAG, n.d.). To quantify the gap, evaluation matrices were designed based on the gap analysis tool, as shown in Appendices D & E. These matrices were formed to be consistent with the method used in the respondent interviews throughout the project. The compliance interviews were conducted unstructured, which, according to David and Sutton (2011), increased internal validity and provided an opportunity for respondents to emphasize their views. These interviews had questions regarding specific topics that extended the understanding of the research area, as presented in Appendix F. However, most of the interviews were based on follow-up questions since the authors had limited knowledge of the specific topic and were therefore unable to formulate questions before the interviews.

4.3.4 Thematic Analysis

The present study employs thematic analysis to revise the findings by utilizing conceptual themes to transform the results into manageable categories, as proposed by Polit and Beck (2010). The development of themes in this research is based on the four stages adapted from the study of Vaismoradi et al. (2016), as illustrated in figure 4.3.

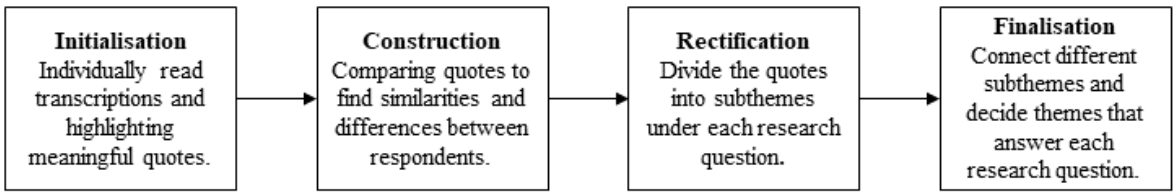

Figure 4.3. Phases in the thematic analysis, adapted from Vaismoradi et al. (2016).

The first stage is initialization, where each author highlighted quotes from the transcribed files and placed them on post-it notes. This process followed the structure of an affinity diagram, as presented by Klefsjö et al. (1999), to ensure a systematic process of determining the themes and to ensure that both authors had the opportunity to present quotes. In the subsequent phase, both authors went through all the notes together to remove duplicates and clarify the notes that were unclear. The notes were then placed on the walls and whiteboard and classified into the research questions they were connected to, which provided an overview of the notes. The

authors then grouped these notes into subthemes under each research question and subsequently grouped the subthemes into themes that addressed the research questions of the report. The final step was to translate, digitize, and categorize the quotes under each subtheme and theme. Each theme was then analyzed, and relevant quotes to be included in the report were highlighted.

4.3.5 Gap analysis

The present study aimed to investigate the implementation of APQP in current project models at Volvo GTO by combining the findings from thematic and theoretical analyses. The thematic analysis was also evaluated using matrices to determine the extent of APQP implementation within the organization. The results were visually presented using a figure, as suggested by Snilstveit et al. (2016), and with color-coding to enhance transparency, as explained by Rosling and Zhang (2011). Lum et al. (2011) further emphasized the importance of presenting findings in a user-friendly manner to increase their utilization.

To analyze the gaps between the current state and the desired future state of APQP implementation, a gap analysis approach was employed, as recommended by Bartusiak et al. (2022). Based on the literature review and thematic analysis, the study provides recommendations on how to bridge the gap between the current and desired states of APQP implementation.

4.4 Research Quality

To ensure the quality and independence of this report, the concepts of reliability and validity have been considered throughout this research project. In qualitative research, it is crucial to express opinions and experiences accurately without manipulating the collected data (Patton, 2001; Rowley, 2012). Reliability is considered in the data collection process, which measures the trustworthiness of data in a research area (Golafshani, 2003; NE, n.d). This project has considered the reliability issues that arise when the data collection process is inductive and interviews are conducted in a semi-structured and unstandardized manner. David and Sutton (2011) describe reliability as the consistency with which respondents perceive the questions. To ensure the questions were presented appropriately, two interviewers participated in the interviews which also gave wider observations (Carter et al., 2014). Conducting the interviews in Swedish further reinforced reliability to avoid misunderstandings and confusion regarding the questions.

Validity is a measure of credibility and quality (House, 2010). According to David and Sutton (2011), validity can be divided into two categories: internal and external validity. Internal validity refers to how well the collected data correspond to the opinion of the studied group, while external validity relates to the information that is applicable to the broader population and not just the sample studied. This project has been conducted using an inductive approach, which can improve internal validity while limiting external validity. Internal validity has been enhanced through the use of semi-structured and unstructured interviews that allowed

respondents to freely express their thoughts and opinions. Changing the question between interviews has further improved the internal validity as it allowed respondents to give their view of the situation and decide the interview's direction. However, external validity has been compromised as the inductive approach does not place much emphasis on generalization (Saunders et al., 2009). Furthermore, the unstructured and unstandardized interviews made it difficult to compare responses to create a generalized view (David & Sutton, 2011). This report has chosen to neglect external validity as it focuses on a specific topic with interviews conducted with certain positions at the organization, which will not reflect the entire organization's perspective. In order to enhance the credibility of the analysis, quotations from the interviews were carefully selected on an individual basis and subsequently compared among the authors to ascertain their relevance. However, it is important to acknowledge that the chosen quotations were categorized according to the research questions, potentially introducing bias into the selection process. To mitigate this bias, each author was required to provide justification for the exclusion of any quotations that were not chosen by both authors.

5 Empirical findings

The following section presents the empirical findings from the theoretical and practical gap analysis that is derived from the conducted interviews.

5.1 Organizational analysis of the current situation

The thematic analysis presented in this section is derived from the interviews conducted and the quotes that form the foundation of this analysis are provided in appendix G. The appendix focuses on organizational analysis and theoretical gap analysis. Additionally, the evaluation matrix generated from the compliance interviews with C5, C6, and C8 is presented in figure 5.1.

	IATF Clauses	APQP	PSM			DVP		
			Level of current implementation	Level of difficulty to implement	Level of complexity to implement	Level of current implementation	Level of difficulty to implement	Level of complexity to implement
			1 = Fully implemented	1 = Not diffcult	1 = Not very difficult	1 = Fully implemented	1 = Not diffcult	1 = Not very difficult
			5 = Nothing in place	5 = Very difficult	25 = Very difficult	5 = Nothing in place	5 = Very difficult	25 = Very difficult
Product development	8.3.3.1	1. Design records PVR, Drawings TR's	4	3	12	1	1	1
	8.1.1	2. Design review + RTS opended	4	3	12	1	1	1
	8.3.2.1; 9.1.1.2	3. DFMEA	4	3	12	1	1	1
	8.3.3.3 8.5.2.1	4. Special Characteristics (CC & SC) Traceability	4	3	12	1	1	1
	8.3.3.2 8.3.5.1	5. Design Review + RTS closed	4	3	12	1	1	1
Process development	9.1.1.1	6. Process flow chart, Process & method description	4	2	8	1	1	1
	9.1.1.2	7. PMFEA	4	2	8	1	1	1
	6.1.2.3; 8.5.1.1	8. Control plan	4	2	8	3	2	6
	7.1.5.1.1; 7.1.5.2.1 9.1.1.1	9. MSA Calibration	4	2	8	3	2	6
	8.3.5.2 8.5.1.2 8.5.1.5	10. Work instructions (WSS, SOP, OPL), Control- & packaging instructions	4	2	8	1	1	1
Validation	9.1.1.1	11. Dimensional report	4	2	8	1	1	1
		12. Material & test report	4	2	8	1	1	1
		13. Initial capability study	4	2	8	1	1	1
		14. Sample products	4	2	8	1	1	1
	9.1.1.3	15. Checking aids (fixtures, test equipment)	4	2	8	1	1	1
	8.3.6.1 8.5.1.7	16. Records of customer specific requirements	4	2	8	1	1	1
Approval	7.5.3.2.1 8.6	17. Part Submission Warrant (PSW)	4	3	12	1	1	1
Change development	7.5.3.2.2; 8.3.6.1 8.5.1.5; 8.5.6 8.7; 9.2.2.1 9.2.2.3; 9.2.2.4	18. Process and method changes	4	3	12	1	1	1
PPAP	7.5.3.2.1	PPAP	4	3	12	1	1	1

Figure 5.1. The developed framework for the theoretical gap analysis, green represents not very complex, yellow represents complex, and red represents high complexity to implement APQP in the project models.

Figure 5.1 summarized the compliance interviews with C5, C6 and C8 and their perceptions of possibilities to replace or combine APQP into the current project models. C5 noted that there is a lack of APQP implementation into the PSM process. C5 further mentioned that there has been no goal to implement APQP into PSM and that there is no ambition to do so in the future. C5 pointed out that implementing all steps of APQP into PSM would not be too difficult, although suggested that it may be more appropriate to keep them separate.

In contrast, C8 reported that most areas of APQP are already fully implemented in DVP, except for two areas that would not be challenging to implement. C8 highlighted that the primary challenge in implementing all steps in DVP is the increasing size of the control list, which becomes difficult to manage. C8 also noted that there will be several points in the control list that may not be used in every project, which could lead to a more theoretical approach with more administrative work.

Theme: New product and processes

The empirical findings on organizational analysis have revealed a theme of new product and process implementation, as indicated by several respondents and illustrated in figure 5.2.

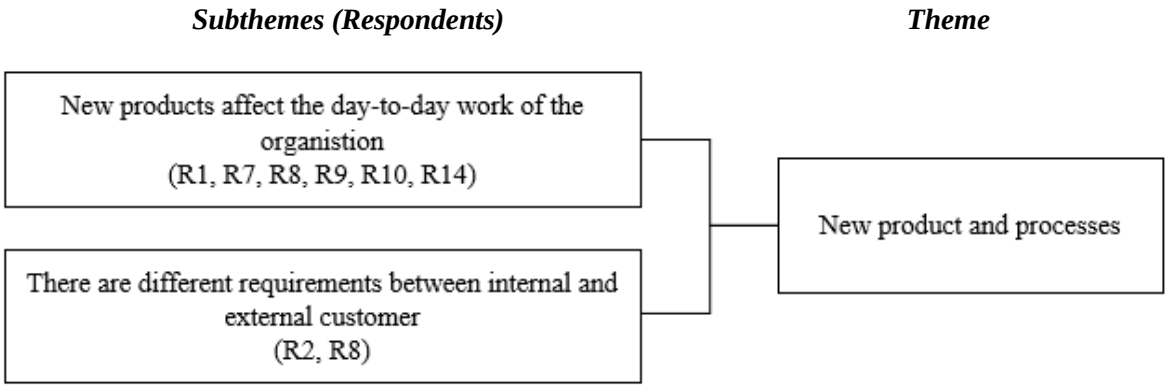

Figure 5.2. Presents theme and subthemes including respondents for the theme new products and processes.

One of the challenges faced by the organization, according to R1, is the adoption of new products and processes, since the organization has been using the same processes and products for an extended period of time. A transition requires the establishment of new routines and processes to ensure that external customers receive the new products efficiently. New product and processes is further substantiated by R7, who notes that the organization is uncertain about the impact of new products on the company's operations and further stated;

> *"When it comes to what we have been producing for many years, we have an understanding of it. But when it comes to the new, we probably do not really know how it works."*

Additionally, R9 highlights that the lack of established networks for new products can lead to issues. On the other hand, R2 suggests that the attitudes of internal and external customers at

Volvo GTO PTP differ, as they have distinct requirements. This inconsistency can lead to credibility issues in the business, with suppliers being required to comply with IATF 16949:2016, but internal business not having the same requirement, as mentioned by R8.

Theme: The business works in silos

One of the themes identified in the interviews was the prevalence of silos within the business, see figure 5.3.

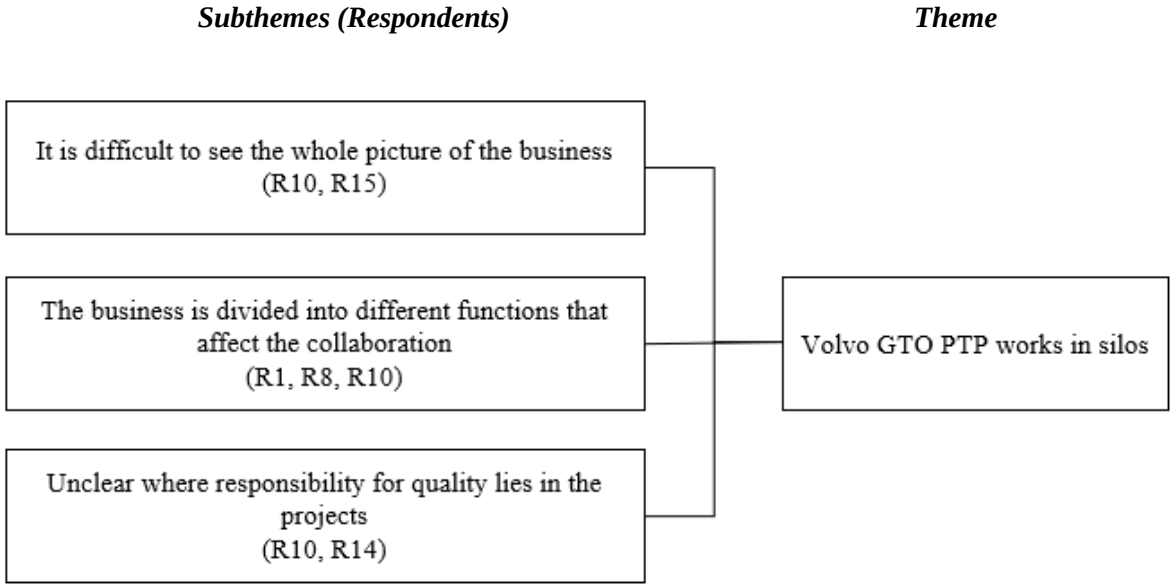

Figure 5.3. Presents theme and subthemes including respondents for the theme Volvo GTO PTP works in silos.

The respondents perceived difficulties in getting a whole picture of the company, as individual departments and divisions often worked in isolation from one another. As R15 noted,

"It is very difficult to know for the head what the tail has done".

It is a common problem within the organization that later processes are not considered when a change is implemented. According to R10, one of the reasons for the silos is that the different divisions do not respect each other, nor do they create conditions for successful collaborations. Furthermore, R1 explained that the different processes, such as foundry, machining, and assembly, at Volvo GTO PTP Skövde, can generate silos. Foundry is a process industry that has different conditions in relation to other operations.

Theme: Time-pressed projects

The projects are perceived as being time pressed, this theme is presented in figure 5.4. The lack of time has resulted in projects skipping steps in traditional project models and proceeding directly to the development and production phases.

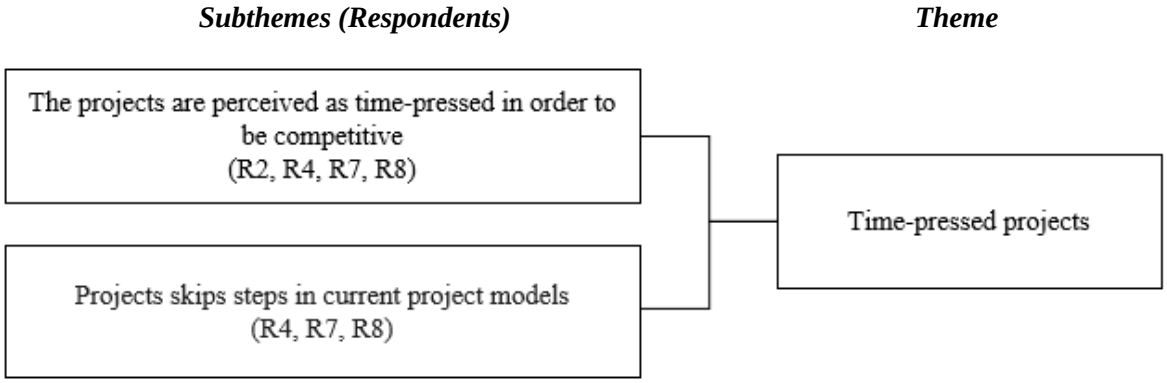

Figure 5.4. Presents theme and subthemes including respondents for the theme time-pressed projects.

The consequences of neglecting phases will become apparent upon project completion, according to R7, a view supported by R8, who notes the challenges of connecting all parts during production. As an illustration, R4 states that;

"Somewhere the delivery becomes so important, that we get the product delivered rather than ensuring what it is we deliver".

The automotive industry faces the challenge of meeting customer demand and maintaining competitiveness, which R7 also acknowledges as a possible basis for time pressure in project management.

Theme: The view of current project models DVP and PSM

During a compliance interview regarding the PSM project model, C5 noted that the model relies on front-loading in theory. However, C5 also pointed out that it can be tempting to skip steps and postpone them for later. C5 went on to describe a recurring issue with time-constrained projects, which creates a vicious cycle where additional resources are required to complete one project on time. To acquire these resources, the subsequent project, which has already begun, must forfeit resources at the project's start, leading to increased workload and a need for more resources down the line. Figure 5.5 illustrates how the PSM project can overlap to cause these issues according to C5. However, the primary challenge, according to C5, is that the organization may not always be able to slow down projects to prevent resource depletion because of legal requirements that might dictate timely completion.

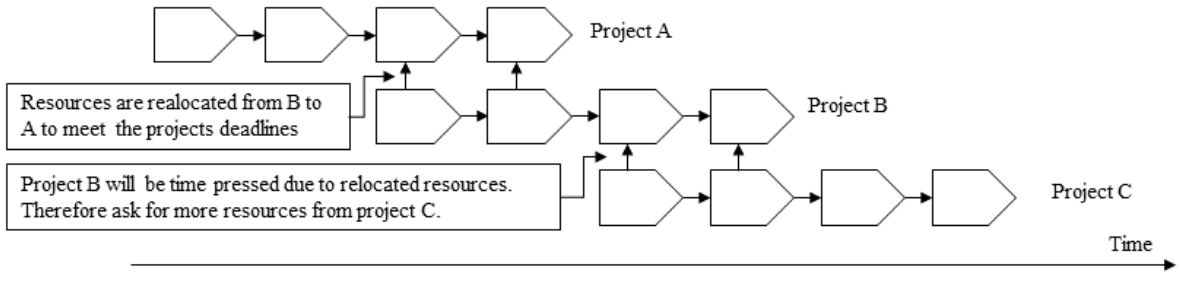

Figure 5.5. Illustration of how PSM projects tend to overlap, according to C5.

The respondents who work with DVP and PSM perceive differences between these models and express opinions on the project models advantages and disadvantages, as illustrated in figure 5.6. According to R5, DVP can be viewed as bureaucratic, while PSM requires less administration. Additionally, R12 finds working solely with PSM to be straightforward, although when combined with DVP, R12 observes;

"It is not very clear what deliveries I expect from the DVP project into the PSM project, and it is not at all clear whether the PSM project should deliver anything back to the [DVP] project at all or not".

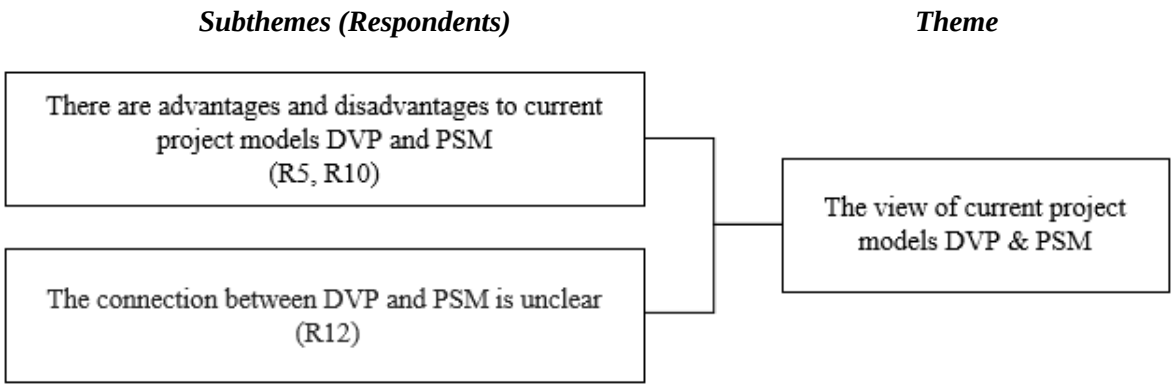

Figure 5.6. Presents theme and subthemes including respondents for the theme the view of current project models DVP & PSM.

Consequently, there is uncertainty about how the connection operates between the current project models of DVP and PSM. Based on the theoretical gap analysis, C5 remarks that integrating APQP into PSM would not be difficult. However, the appropriateness of having everything in PSM remains unclear. Instead, C5 proposes that APQP could be an add-on to PSM, similar to how other models currently function. C8 notes that DVP has implemented APQP steps, but as R5 also points out, creating a checklist for everything can result in a significant amount of administration.

Theme: Familiarity with quality standards

The section highlights a weakness in the organization where employees lack familiarity with the quality standards employed by the company. It is supported by R4's statement about IATF 16949:2016, who states that;

"The way we talk about it here, I would say that it exists at certain levels at the MTM and MTS level, where there is control of what is needed, but I don't feel that it is spread throughout the organisation."

Some respondents in the study were not familiar with the standards, while others had heard about them, but the connection to the business was unclear, see figure 5.7.

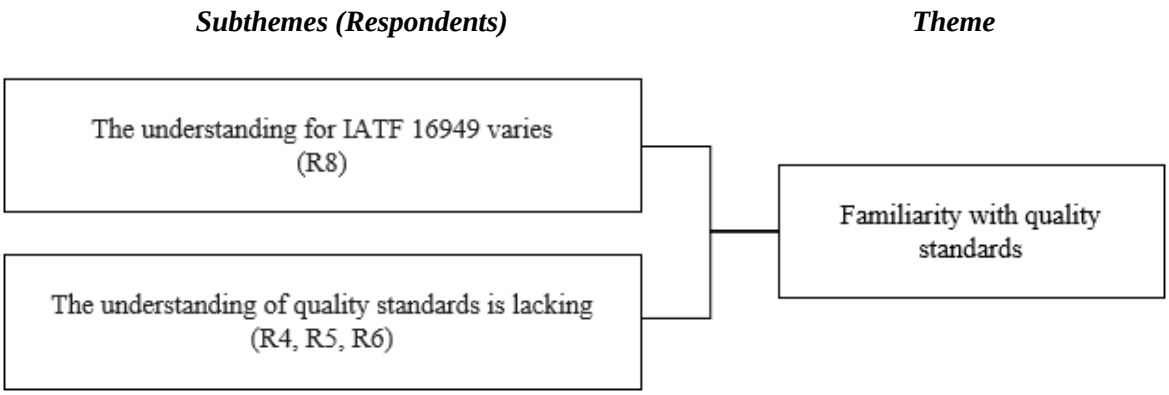

Figure 5.7. Presents theme and subthemes including respondents for the theme familiarity with quality standards.

The lack of familiarity affects attitudes towards the certification process, as evidenced by R8's divided attitude towards certification, where the value of certification is debated. While R8 recognizes that an IATF 16949:2016 certification may not create value in itself, the respondent argues that the organization must create the necessary conditions to meet the requirements for the standard to develop quality assurance, production planning, and industrial processes.

5.2 Organizations' understanding of the APQP model

This section presents the relationship between thematic analysis and practical gap analysis. The data obtained from the interviews has been examined through the thematic method and is illustrated in Appendix H. Figure 5.8 provides an overview based on the responses from the interviews. The APQP model reveals that phases 10 and 18 are the most comprehended stages in the organization concerning what actions should be taken and how to manage changes in production. However, phase 9, 15, 16, 17 and Production Part Approval Process (PPAP) are areas where the organization lacks comprehension of the individual role of each respondent and how these areas apply to their work. The remaining phases are known to the respondents, although their level of involvement differs across the organization. Some respondents are actively involved in these stages, while others only possess a shallow understanding of the topic.

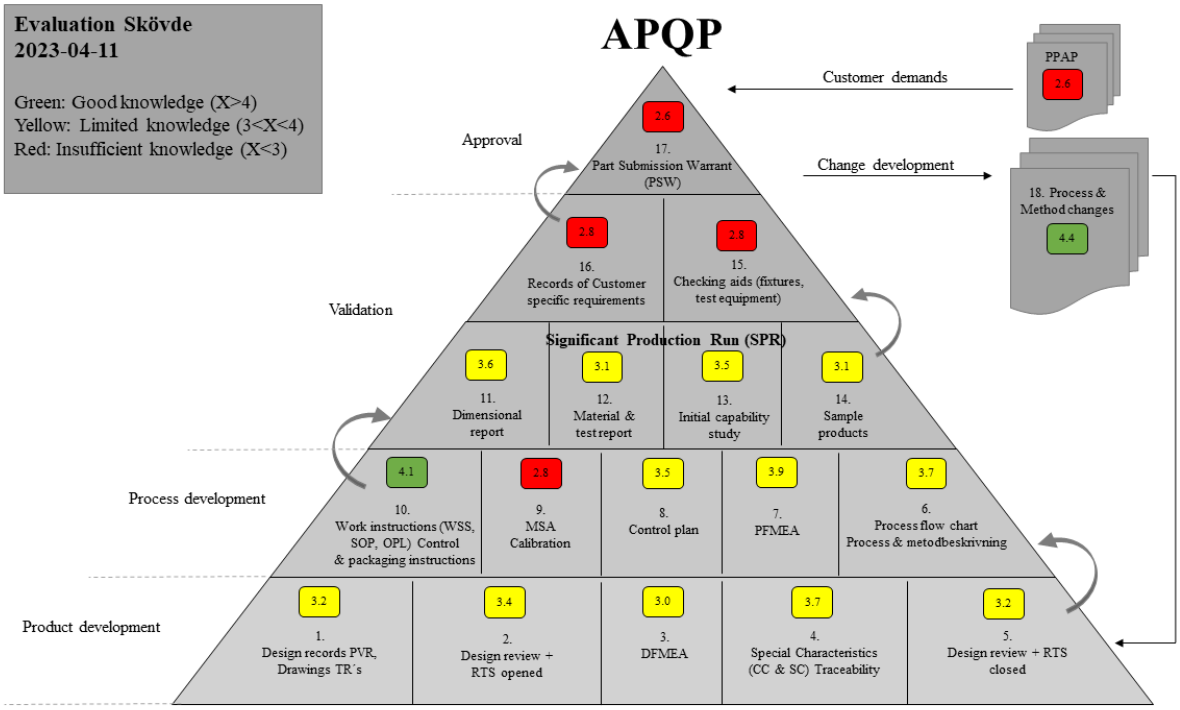

Figure 5.8. An overview of the understanding for the APQP model and the evaluation.

Theme: Structure of the APQP model

The structure of the APQP model was a topic that emerged from the thematic analysis, and it is illustrated in figure 5.9. There were diverse views on the model's structure, which is designed as a pyramid to indicate that the majority of the project's time should be dedicated to product development to establish a foundation for subsequent phases in which Volvo GTO PTP takes over the product and initiates process development. Nevertheless, according to R4, some individuals have a limited perspective and view the model as a one-time event that has already been determined to be completed.

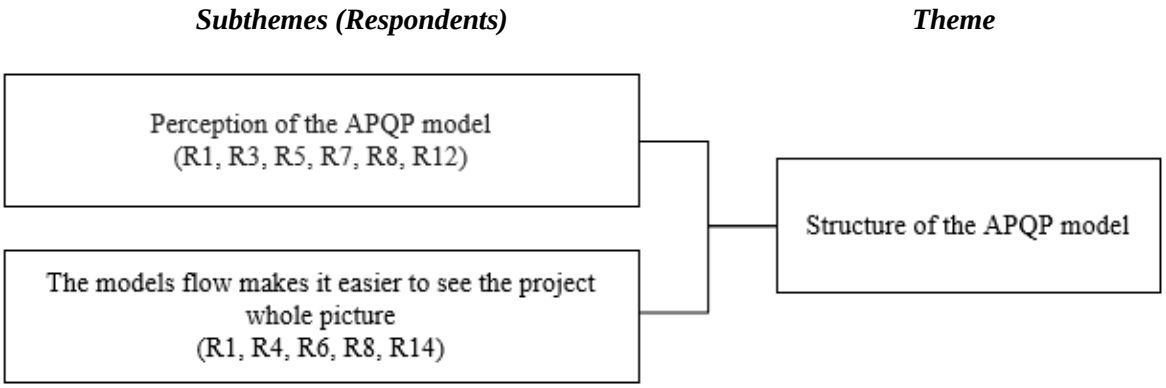

Figure 5.9. Presents theme and subthemes including respondents for the theme structure of the APQP model.

It is essential to comprehend the entire model and how the activities are interconnected. For example, R1 pointed out the difficulty in preparing a control plan without first completing the previous steps, while R12 stated that the organization struggles to grasp the relationship between DFMEA and PFMEA in managing product and process risks. There were differing opinions on the model's flow, with R6 stating;

> *"We have followed the pyramid, maybe not always in the right order, we have worked some here and some there [referred to pyramid]. We do not get done, instead we come to a distance and then loop".*

This iterative process is how the model should be implemented, with teams revisiting previous steps if modifications are necessary, and updating them in accordance with the latest product or process development. However, as R1 noted, there is always the risk of individuals taking shortcuts, which may occur when projects need to be completed quickly, as discussed in section 5.1.3.

Theme: Managing and ensuring working methods

One of the inquiries directed to the respondents was regarding how the organization manages risk during the development of products and processes. Figure 5.10 presents an overview of the subthemes connected to how the respondents perceive the handling of different methods. The aim is to comprehend how the organization operates with reactive and proactive risk management concerning the significant characteristics (SC) and critical characteristics (CC) requirements. Volvo GTT establishes the CC and SC requirements that Volvo GTO PTP needs to work with in their process development.

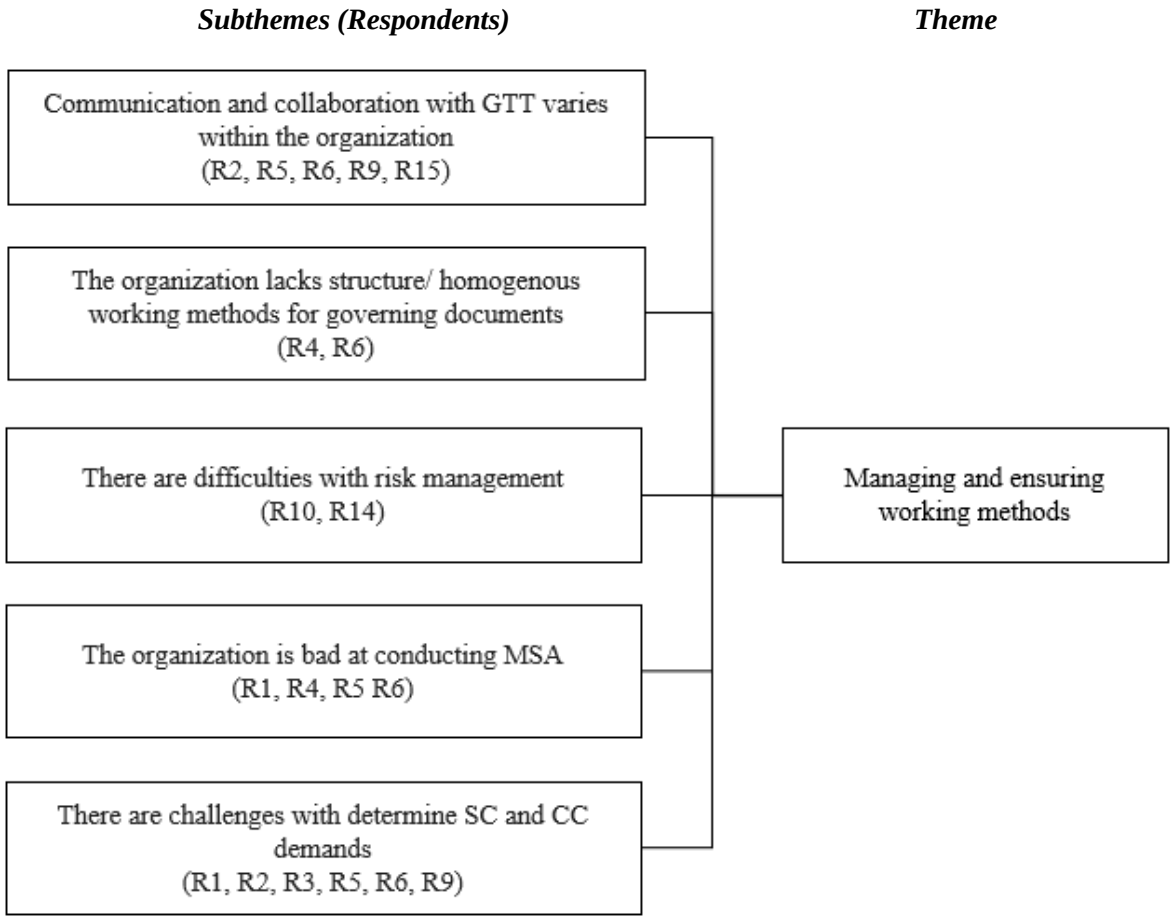

Figure 5.10. Presents theme and subthemes including respondents for the theme managing and ensuring working methods.

R5 mentioned that the organization has improved in handling CC and SC requirements, although some areas still require attention. As this is a new working method, some products have not yet been transferred to the new approach, as stated by R2 in the interviews. Risk management also poses a challenge as mentioned by R14, who stated that;

"It is difficult to catch the unknown unknowns, meaning things we do not even know that the risk exists, these are hard to catch".

It is essential to have a mindset that manages work methods to avoid putting aside possible risks and to understand the product and process. For instance, R6 does not want to participate in determining the CC and SC requirements as the respondent experiences a lack of knowledge of the product to evaluate potential risks. The transformation to new products also implies that the organization needs to be educated in new ways of working and thinking.

R1, R4, R5, and R6, pointed out that MSA can be challenging to conduct. R5 mentioned that MSA is not conducted at all, which could be due to a lack of competence and resources. This relates to what R6 mentioned, as their project has not yet reached the MSA phase, and the respondent feels unsure of what it entails. Figure 5.8 shows that MSA is a critical activity that

not many are aware of, and it is unclear who is responsible for the activity compared to work instruction in step 10, where many understand the meaning of the activity and can apply it to the organization's processes. Compliance interviews with C8 revealed that step 10 is fully implemented in the DVP model, whereas MSA is not. Additionally, C3 and C4 mentioned that MSA is an area that the organization needs to work on. C6 highlighted that;

> *"We also need to get better at doing that [MSA] when we buy equipment. Really check so that the measurement equipment delivers the correct values. Overall, I think we are actually quite bad at it. Probably trusting too much, perhaps trusting the supplier that they have set everything up correctly."*

Theme: Responsibilities and ownership in the organization

One of the themes that emerged from the interviews was the responsibility and ownership of the process within the organization, as illustrated in figure 5.11.

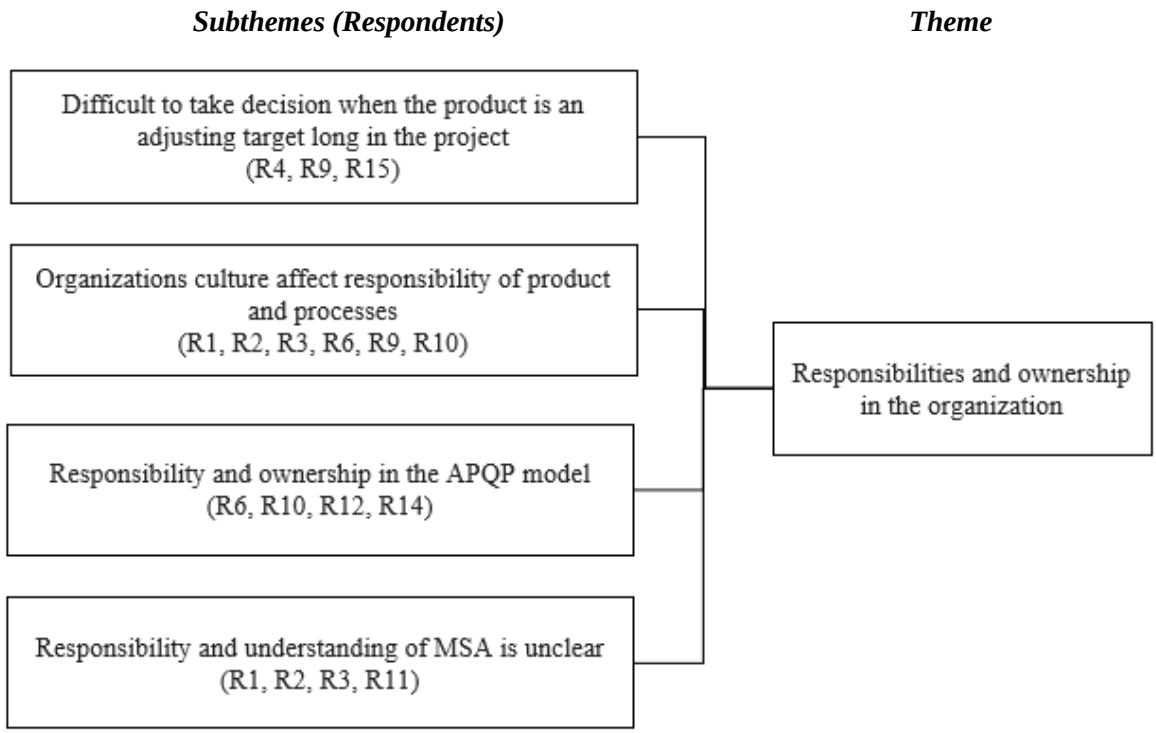

Figure 5.11. Presents theme and subthemes including respondents for the theme responsibilities and ownership in the organization.

It is apparent that the organizational culture can influence the distribution of responsibilities between the foundry, machining, and assembly divisions. R2 commented that,

> *"They call from the assembly and they can not assemble this and that. But we only check that they [machining] follow the drawing, so they have to solve it in that case".*

This statement is comparable to what R10 observed, where people claim they do not have sufficient time for some tasks, even if it is part of their job description. This mindset can impact

the organizational culture, and a proper communication link between activities is important. Nevertheless, this communication link should indicate that a stage in the APQP model is concluded and updated. There is a problem when a handshake is completed when a process is not yet finished, as R10 explained further:

"The responsibility to produce goes over to production and then you can think whatever you want about the product. It is not done, well we have shaked hands".

The subthemes of responsibilities and ownership in the pyramid, as well as the responsibilities and understanding of MSA, are indistinctly correlated with each other due to a lack of experience, as presented in figure 5.8. R12 noted that MSA is a black box and is unsure about what occurs inside it. Furthermore, R3 is not involved in the MSA process and cannot identify what it produces for the projects, even though they think that others have the knowledge. This pattern in the pyramid is evident, where the respondent discusses the responsibilities of other individuals and not their own. For instance, R1 mentioned,

"If we do figure out what to measure, I am pretty sure we will do it. After all, we have good, quite good competence in our lab rooms and measuring rooms, as long as we know what to look for, we will do it".

The respondents' remarks regarding the difficulty of taking action for late changes vary. R4 explained that it would be difficult to determine which machines to purchase and install since the design review has not yet been completed. It becomes challenging to order something when the design is not finalized, and alteration can affect the process. R9 stated that,

"The product is a moving target very far into our projects".

This statement indicates that one does not have fixed decisions before commencing the process development, and not having a complete DFMEA can result in potential risks in later stages in the pyramid and increase reactive work instead of working preventively.

Theme: Competence development

The study conducted a thematic analysis to examine the knowledge of the APQP model within Volvo GTO PTP. The findings, as illustrated in figure 5.12, suggest that the organization had a limited understanding of the APQP model. Specifically, the areas where respondents indicated their awareness were marked in red and yellow in figure 5.8.

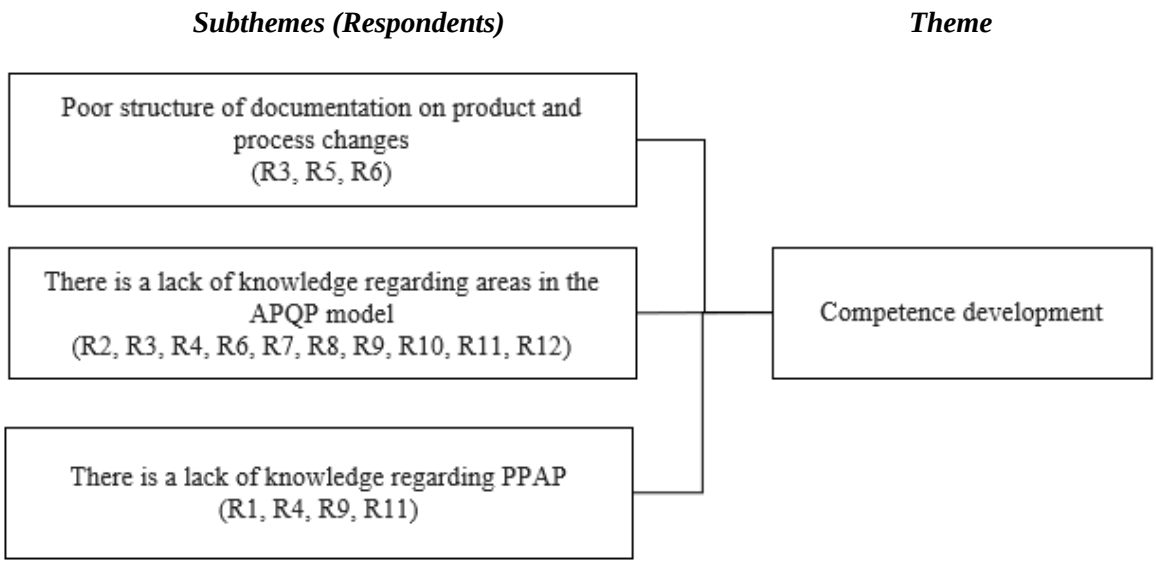

Figure 5.12. Presents theme and subthemes including respondents for the theme competence development.

However, the discussions among the respondents indicated that they did not fully comprehend the significance of these areas, particularly with regard to ensuring that product and process changes are adequately addressed and that existing documents are updated, as highlighted in phase 18 of the APQP model. R6 acknowledged the lack of knowledge regarding the methods for product change, stating;

"How to ensure that you really do this step again, I do not know if there is any particular one [method for product change]."

Although the pyramid in figure 5.8 indicates that phase 18 was understood by most respondents, the study revealed that some individuals were still uncertain about how to handle changes. R3 also confirmed this finding. Prior to initiating new projects, the organization carries out case studies to identify how previous projects addressed risks and process development, which are documented in white papers. However, some respondents expressed difficulty in accessing these papers. For instance, R5 described the process as detective work, given the varying levels of documentation and the difficulty in locating relevant materials.

The study also identified a lack of familiarity with the PPAP, which could be attributed to the fact that the organization is not a supplier. As noted by R1;

“We want all our material we buy that comes in to have PPAP on it, we do, but we are not that familiar with the actual PPAP process ourselves yet”.

However, respondents, R6, R9 and R11, expressed their lack of knowledge regarding the PPAP process, while R4 observed that the term is not used in the foundry.

5.3 Bridging gaps in the APQP model

This section aims to present the empirical findings focusing on bridging the gaps in the APQP model. To achieve this, data collected from interviews was divided into themes using the thematic method, which is presented in appendix I.

Theme: Clear involvement of different functions in the APQP model

The respondents expressed a desire for the quality department to play a more integrated and supportive role in projects. This sentiment is supported by R5 who says that;

"You need to have a quality preparer in the projects which do this, who has competence and administration skills [pyramid]".

Failure to involve the quality department early on in the project can have a negative impact on the "red thread" through the APQP model, which is emphasized by R6 during the interview. The APQP model comprises different phases, as illustrated in figure 5.13, and the participants stress the need for clear transitions between these phases, as well as effective collaborations between different functions within the organization.

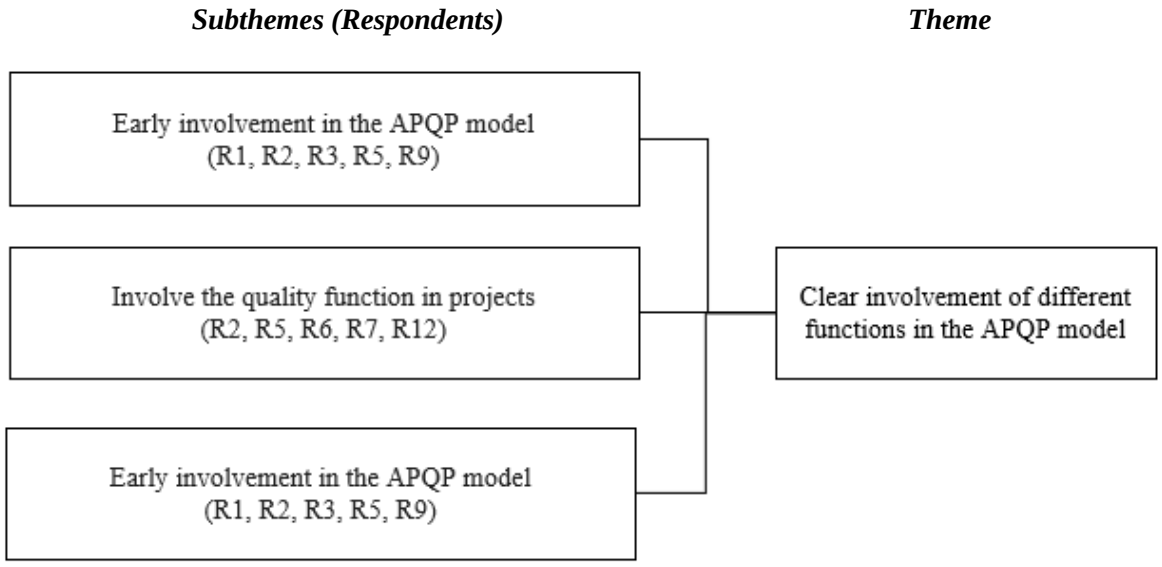

Figure 5.13. Presents theme and subthemes including respondents for the theme clear involvement of different functions in the APQP model.

Respondents, such as R3, R5, and R10 suggest early involvement in the APQP model to develop a better understanding of the activities and decisions made between the Volvo GTT and Volvo GTO PTP. R3 and R5 also emphasize the importance of collaboration between these divisions to establish the prerequisites for success in product and process development. R10 highlights the significance of spreading knowledge of the APQP model to all stakeholders, as it is currently perceived as a burden by some, as stated by R4;

"I think it is good to spread the understanding that a person should do something and not see it as a burden. You also have to understand the consensus of it".

Early involvement of interested parties in projects can foster collaboration and clear handovers between activities within the APQP model, as noted by R10. However, R8 cautions against implementing APQP in its entirety immediately as it may lead to project delays and difficulties in managing the current work processes. Instead, R8 recommends a gradual implementation of APQP.

Theme: Difficulties for activities in the APQP model

The respondents have reported difficulties in developing DFMEA and PFMEA, as presented in figure 5.14.

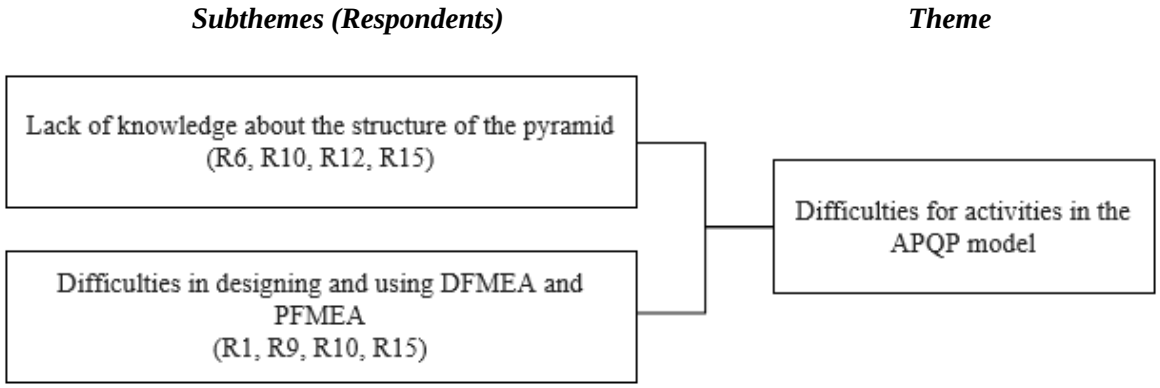

Figure 5.14. Presents theme and subthemes including respondents for the theme difficulties for activities in the APQP model.

Due to the complex operations of Volvo GTO PTP, require involvement of multiple stakeholders leading to varying evaluations. R6 states that;

"We need to understand if we make a change then after the change, I have to redo these steps [in the pyramid]"

Furthermore, R10 has emphasized that a yellow mark signifies that the action plan has been developed and is currently up-to-date, whereas a red mark indicates that it is yet to be accomplished. It is crucial for the organization to understand the distinction between these marks to ensure that the execution and application of the plan have been performed correctly.

Theme: Opportunities in the APQP model

R4 explained the importance of demand for deliveries in the context of the APQP model, as failure to comply with audit requirements and the presence of delivery demands could lead to shortcuts. This aligns with the findings of figure 5.15.

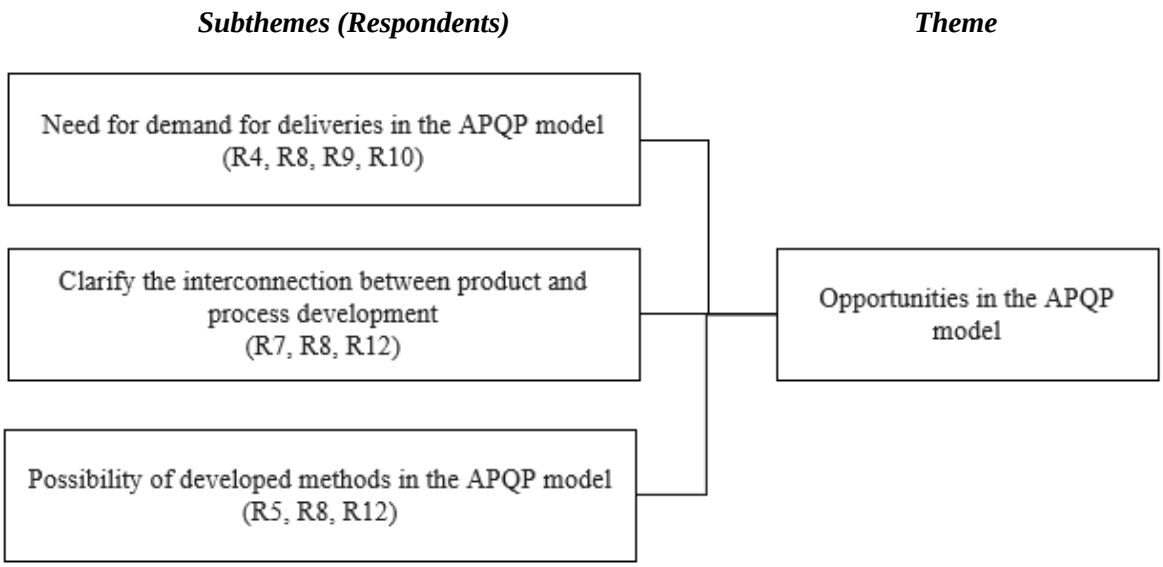

Figure 5.15. Presents theme and subthemes including respondents for the theme opportunities in the APQP model.

Additionally, R8 noted that there is currently a lack of in-depth inquiries regarding project deliveries, whereas R9 stating that;

"If you do it rarely, you will not get good at it."

This statement highlights the necessity for organizations to integrate the APQP model into their daily operations to achieve optimal results for product and process development.

6 Analysis of Theoretical and Empirical Findings

The section presents analysis between the theoretical framework and empirical findings. Appendix J presents an overview of the different research topics and how these affect each other.

6.1 Analysis of the current organizational situation with current project models

Volvo GTO PTP Skövde has been producing the same products for an extended period of time. However, the market demand for sustainable solutions has increased significantly, as noted by Illés et al. (2017, chapter 2.2). To address these sustainability challenges, Benabdellah et al. (2020) argue that constant innovation and flexible solutions are necessary. Similarly, Laskurain-Iturbe et al. (2021) explain that IATF 16949:2016 can provide opportunities for flexibility in customer service.

The transformation of the market has forced organizations like Volvo GTO PTP to adapt to remain competitive (Beer & Nohria, 2000). This requires a cultural transformation and the disruption of entrenched ways of thinking, as noted by R1, R7, R8, R9, R10, and R14. Garvin and Roberto (2005) illustrate that cultural changes affect the prerequisites for product and process development. The empirical study presented in figure 6.1 shows the correlation between themes related to this cultural transformation.

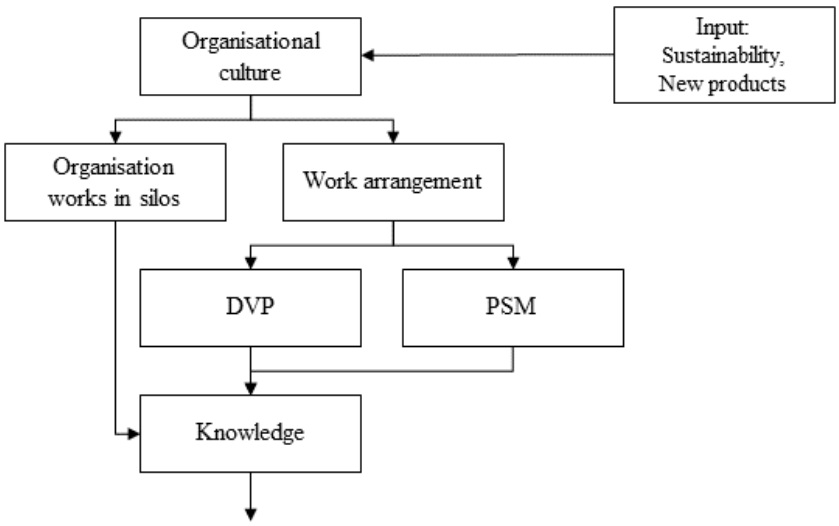

Figure 6.1. Themes from the empirical study related to organizational culture.

According to R10 and R15, the current culture at Volvo GTO PTP makes it difficult to see the entire supply chain. This lack of visibility has led to silos within the organization, affecting collaboration between foundry, machining, and assembly (R1, R8, & R10). These silos can

inhibit motivation for quality improvement as the organization must understand the benefits, as argued by Aggelogiannopoulos et al. (2007). QMS affects development, production, installation, maintenance, and project management implementation, according to Franceshine et al. (2011). Van der Wiele et al. (2005) further note that QMS can affect the organization's structure.

Projects within Volvo GTO PTP have been observed to occasionally skip steps in the current project models and directly engage in product and process development. This approach leads to a lack of basic prerequisites for achieving the desired project outcome, resulting in around 40% of product projects failing, as stated by Cooper (2017) and supported by Cooper et al. (2004). Poor preliminary work is identified as a reason for project failures in a study by Cooper (2019). Respondents R2, R4, R7, and R8 mention a time shortage that affects project work arrangement in the current project models. The current project models at Volvo GTO PTP are the DVP and PSM, built upon models developed by Cooper (2017) and similar to the generic project model adapted by Tonnquist (2021) and Ornelid (2023). However, time-pressed projects create an "evil circle", according to C5, due to the reallocation of resources between projects.

R5, R10, and R12 identify differences in bureaucratic and administrative conditions between DVP and PSM in terms of work arrangement. The empirical study shows that the relationship between the two project models is perceived as uncertain and diffuse. C5 and C8 note that there is no clear connection between the models, which Tonnquist (2021) considers important to prioritize and communicate activities between projects, supported by Ornelid (2023). Additionally, there is a lack of knowledge regarding quality assurance standards that the production industry is built upon. Respondents R4, R5, R6, and R8 have divided opinions on quality assurance standards, especially regarding whether Volvo GTO PTP should obtain an IATF 16949:2016 certificate. Afriyuddin et al. (2019) demonstrate that an updated ISO 9001 resulted in increased productivity and reduced the number of defects within an automotive company. The standard also affects QMS, which correlates to manufacturing performance according to Fahimi et al. (2021). According to IATF (2022), an update to IATF 16949:2016 means an increased opportunity to meet customer specific requirements by 23% compared to only being ISO 9001:2015 certified. Furthermore, Ellis (2019) claims that IATF 16949:2016 can establish necessary foundations for profitability and customer relations through quality improvements and reduced defect costs.

6.2 Analysis of the organizations' understanding of the APQP model

The findings of the present study indicate that the comprehension of the four phases of the APQP framework varied among the respondents. Specifically, respondents identified phases 9, 15, 16, 17, and PPAP in the pyramid as critical activities, as illustrated in figure 5.8. The respondents' understanding of APQP phases and involvement in the different stages of the model varies across the organization.

ISO (2015) stresses the importance of considering stakeholders, process development, and responsibility to positively impact decision-making in the organization, which is supported by Bergman and Klefsjö (2020). In addition, the study presents a correlation of the themes from empirical studies that explain the knowledge of the APQP model at Volvo GTO PTP in Skövde, as presented in figure 6.2.

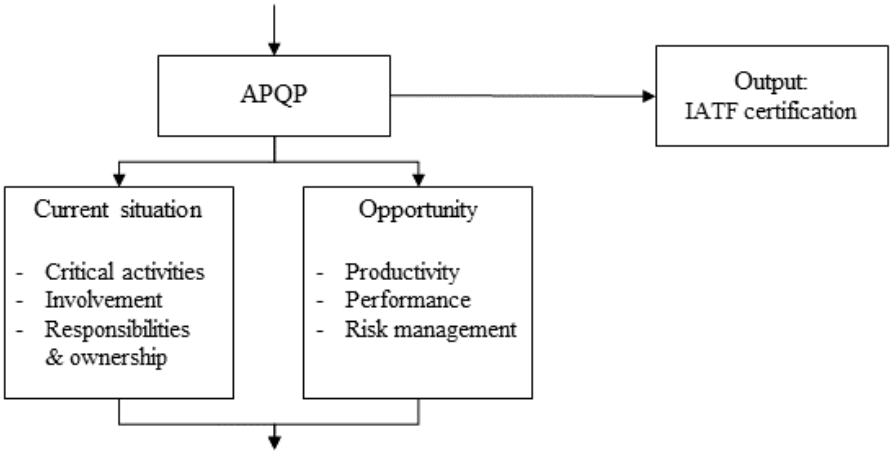

Figure 6.2. Presentation of the themes that explain the current situation at Volvo GTO PTP.

Some respondents (e.g., R12) reported difficulties in comprehending the earlier phases of APQP and incorporating ongoing activities, such as the PFMEA that builds on the results of the DFMEA. Furthermore, R4 states that the model could be seen as individual activities. However, Browning et al. (2006) argue that an established framework can enable knowledge management, which is evident in the current project models at Volvo GTO PTP that use past knowledge to manage ongoing projects. Mittal et al. (2012) contend that a well-functioning APQP strategy can enhance the productivity of the product and process development. Furthermore, Rousch et al. (2008) demonstrate that product planning can avoid and manage late changes in product and process development.

Notably, respondents (e.g., R4, R9, and R15) reported that the product at Volvo GTO PTP is a moving target, causing reactive work methods and leading to shortcuts to meet project deadlines (e.g., R1). Such practices increase the risk of stakeholders losing trust in the company's products (Bergman & Klefsjö, 2020).

Risk management has become increasingly important for organizations due to the decreased business opportunities since the financial crisis in 2008 (Rabechini Junior & Monteiro de Carvalho, 2013). There is a correlation between risk management and project success. IATF 16949:2016 was developed to focus on, among other things, risk management to meet increased quality requirements within the automotive industry (IATF, 2022). Furthermore, Rabechini Junior and Monteiro de Carvalho (2013) suggest that appointing specialists that only focuses on risk management increases the chances for project success by four times.

According to R14, it is difficult to detect risks early when one does not know what can affect product and process development, hence the reactive approach that Volvo GTO PTP works with. A transition for Volvo GTO PTP implies cultural changes to increase knowledge within the organization. C8 states that DVP, see figure 5.1, does not incorporate MSA, which a transformation towards IATF will require. Furthermore, R1, R2, R3, and R11 state different opinions on who is responsible for conducting MSA. Cooper and Sommer (2018) state that risk management should be handled with clear communication throughout the implementation phase. In this study, it has shown that there needs to be better communication between the phases throughout the APQP model.

6.3 Analysis of how to bridge the gaps in the APQP model

Given the new customer demands for sustainability, there are requirements for companies to transform, thus IATF 16949:2016 can serve as a tool to focus on customer requirements and waste reduction (DNV, n.d; IATF, 2022). Figure 6.3 illustrates the correlation between opportunities for APQP to bridge gaps at Volvo GTO PTP in Skövde. APQP complements IATF 16949:2016, and for Volvo GTO PTP, it serves as a tool to transition their operations to deliver products to external customers. R8 suggests a gradual transition to APQP to achieve wider adoption at Volvo GTO PTP. Kotter (2007) supports this and suggests that a forced change can negatively affect the shift, requiring the management to be aware of a transformational change initiative. Furthermore, Wardhani et al. (2009) emphasize the need for management involvement in the change. Additionally, it is important that the managers are perceived as role models and lead the change (Piskar & Dolinsek, 2006). R10 highlights the importance of knowledge spreading throughout Volvo GTO PTP. Additionally, R4 mentions that IATF 16949:2016 has not been sufficiently spread throughout the organization, which APQP is based on. These are common problems for companies to create commitment, coordination, and competence according to Beer et al. (1993).

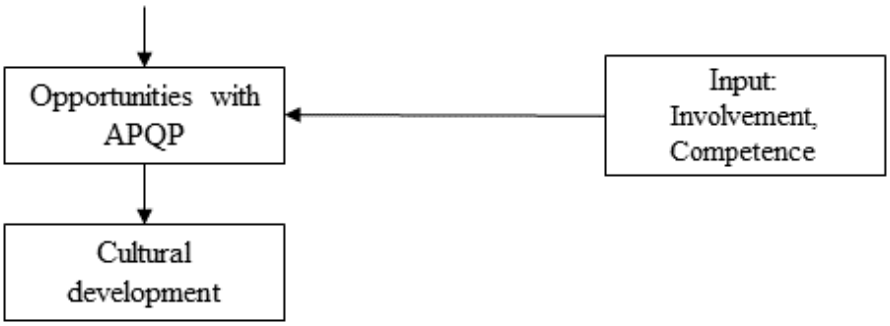

Figure 6.3. Illustration of the theme opportunities with APQP and relation to cultural development.

Volvo GTO PTP in Skövde bases its corporate culture on Theory O, which Orlikowski (1993) describes as a soft approach focusing on culture and human aspects. Moreover, Garvin and Roberto (2005) suggest that changing behaviors can be challenging due to convenience and habitual work arrangements, which can hinder the willingness for change at Volvo GTO PTP, which has been manufacturing the same products for a long time. Organizational change can

be limited by employees' reluctance to change, affecting corporate culture and performance (Kegan & Lahey, 2001). R4 suggests that APQP should not be seen as a burden but as an opportunity for the organization to improve its product and process development using the APQP model. Furthermore, there must be a demand for the work performed in the phases to become proficient in the approach and loop phases when changes occur, according to R4, R6, and R9. Volvo GTO PTP's organizational culture is based on soft approaches, Sirkin et al. (2005) suggest that it is not sufficient for an organization to undergo a transformational change. Two out of three changes fail because there is too much focus on soft change factors. Therefore, Beer and Nohria (2000) recommend combining Theory E and Theory O to increase profitability and productivity. The demand from APQP can be seen as a hard approach, and as previously mentioned, if there is no demand, steps will be skipped, knowledge will disappear, and the organization will not meet customer demands. Therefore, Sirkin et al. (2005) recommends involving a hard aspect in organizational change, and the DICE method could be applied to bridge transformational gaps, see figure 3.8.

7 Conclusion and Recommendation

The section presents conclusions derived from the analysis, followed by recommendations for Volvo GTO PTP to consider when implementing the APQP methodology.

Volvo GTO PTP in Skövde is transforming to meet the demand for sustainable transportation solutions, which creates an opportunity to provide products to external customers. This presents an opportunity to obtain the IATF 16949:2016 certification, a quality management standard for the automotive industry. The certification would enhance the company's reputation, improve efficiency, reduce costs, and increase customer satisfaction and profits. It is imperative for Volvo GTO PTP to pursue this opportunity to remain at the forefront of the industry.

7.1 Comparison between DVP and PSM with the APQP model

The first research question that this report investigated was *"What is the current status of the DVP and PSM project models, which satisfy the requirements of ISO 9001:2015, and how do they compare to the desired APQP model that follows the IATF 16949:2016 standard?".* The question evaluates the potential of incorporating APQP in Volvo GTO PTP current project models (DVP and PSM) or replacing them, to enhance the development of both products and processes. Volvo GTO PTP needs to adopt new working methods that can approve both products and processes simultaneously to meet customer requirements. APQP provides the required flexibility to meet these requirements, and it is recommended by the quality standard IATF 16949:2016 (IATF, 2016; Laskurain-Iturbe et al., 2021).

To analyze the differences between IATF 16949:2016, APQP, and the current project models, a cross-mapping framework was developed and presented in figure 5.1. The framework indicated that there are some similarities between the approaches, suggesting that APQP could complement PSM but not entirely replace it. PSM is a generic model applicable to any type of project, while APQP focuses more on product and process development. However, it is crucial to consider the entire product and process development that APQP contributes to, indicating that DVP can be entirely replaced. Although, the administrative work needs to be optimized to facilitate the use of APQP and mitigate risks of skipping steps because of workload.

7.2 Phases to consider in the APQP model

Answering the second research question regarding *"To what extent has the APQP methodology been implemented within the organization, and how widely is it used across different functions?".* The APQP model is divided into six categories, which is discussed in the following section and what conclusions could be drawn from the analysis.

Product development

The purpose of the product development phase in the pyramid is to identify and eliminate potential risks through design, which leads to less reactive work. The pyramid (figure 5.8) reveals that the organization is aware of all the steps in product development. However, there is a lack of knowledge on how to carry out these steps and an understanding of why they should be implemented. This is largely due to the organization's difficulty in seeing the entirety of the projects, where the steps are interdependent. The critical points of the product development phase are the DFMEA as well as the CC and SC requirements. The results from product development, particularly from the DFMEA and special characteristics phases, should be passed on from the GTT to the GTO team, which will manufacture the products and develop a production process. This requires GTO to understand the critical characteristics when developing the process and to determine how the critical parameters should be measured. It is also important to consider the DFMEA when GTO develops a PFMEA. Therefore, communication between GTT and GTO is crucial, and the current lack of it poses a danger to the business.

Process development

From a process development perspective, it is important to consider risks that could not be handled in the product development. This requires effective communication between the GTT and GTO, which is currently lacking. Respondents have pointed out that communication between construction and production is often ineffective, which does not create conditions for successful project completion. For instance, the product can be a moving target well into the project, and the connections between DFMEA and PFMEA are not always explicitly described. The lack of a clear connection makes it more difficult to identify process risks. However, it is evident that the organization has a comprehensive understanding of how a PFMEA should be conducted, but there is a lack of understanding of how the identified risks should be managed. There are significant gaps in the organization when it comes to control planning and, especially, MSA. There is a general lack of knowledge about how to conduct MSA and why it is necessary. There is also a lack of understanding of who is responsible for performing MSA.

Validation

The validation phase considers validating the product and process to develop the capacity and capability to meet customer requirements. Respondents have reported that the product is a moving target, even in later stages of the project, which affects the development of the process. As a consequence, the process is developed for a product that becomes outdated, resulting in a concept that potentially does not meet customer requirements. Moreover, some respondents lack an understanding of the phases and purpose of process development in the context of Significant Production Run. Two areas of validation that show significant deficiencies are (15) Checking aids and (16) Records of customer requirements, where knowledge and responsibility for execution are lacking.

Approval
Before commencing mass production, processes must be frozen and verified to meet customer requirements. This phase is critical, as there is uncertainty regarding who is responsible for performing the approval and managing the handover to production, as well as who requests the work. Therefore, it is recommended to specify who performs the approval and informs the project teams of their responsibilities.

Change development
When a product or process change occurs, the phases in the pyramid must be repeated. The company currently has a procedure for managing changes; however, employees sometimes neglect to document all adjustments. This is an inadequate approach that will affect the looping of the phases in the APQP model. The consequence will be that the product fails to meet the customer requirements that were previously established, and the customer is not informed of the changes. Additionally, a lack of knowledge within the pyramid will cause employees to avoid executing phases in the pyramid, as they do not understand how the phases are interdependent and how they should be performed.

Customer demands
This phase discusses how to verify that the product delivered meets the customer requirements. This phase is critical, as indicated by the responses of the respondents, and it is due to a lack of knowledge. The company is an OEM that has not previously delivered products to external customers. The transition means that future customers may request PPAP documentation. Therefore, it is considered important to involve management in the step of requesting PPAP documents internally. The reason is to initiate an organizational learning process of the working method and to be prepared for future customer demands.

7.3 Suggested implementation of APQP

The study has indicated that organizational culture is a significant barrier to the effective implementation of APQP, with respondents frequently experiencing obstacles when discussing and working with APQP. Thus, answering the third research question *"How can gaps in organizational knowledge and implementation of the APQP model be bridged?"*. Another barrier is how risk management has proven to be one of the most difficult aspects of APQP. It is recommended to apply the advice from Rabechini Junior and Monteiro de Carvalho (2013) to appoint specialists that focus on risk management.

The company operates based on a soft cultural approach, which is a positive aspect. However, to achieve a transformational change, the consideration of hard aspects is also necessary. Studies have shown that a combination of approaches can enable the direct and indirect impact of changes to be measured. Furthermore, a motivating leadership that fosters commitment, coordination, and competence is essential. Thus, it is significant for the company to review its organizational culture and analyze its work with Theory E and O. Additionally, it is recommended to employ the DICE method, as shown in figure 3.8, to guide the use of hard approaches during a transformational change.

Another approach that the company should consider for an effective cultural change is to analyze the responsibility between the phases in APQP. This can be achieved through cross-mapping, where the responsibilities are defined for the phases in APQP and their corresponding inputs and outputs. Through this process, the company can create demand between the phases and gain an understanding of how the activities are interdependent.

8 Discussion and Contribution

This section gives a discussion of the result and the contribution to the Volvo GTO PTP and external organizations. Furthermore, the study's limitations are presented, along with recommendations for future research.

8.1 Discussion

The study examines the application of the APQP model in the operations of a specific company. The company under investigation was Volvo GTO PTP in Skövde, which functions as an OEM in the automotive industry. It should be noted that the findings of this study may not be universally applicable to all OEMs within the automotive industry due to the supplier-specific nature of IATF 16949:2016, which is the automotive industry standard. However, the study's findings and methodology could potentially be relevant to other automotive companies and manufacturing industries, although adjustments would need to be made to accommodate each organization's specific circumstances. It is important to acknowledge that the external validity of the study may be limited since the gap analysis of the project models is based on a select group of individuals and cannot guarantee a comprehensive representation of the organization's utilization of APQP. Nonetheless, the results can be considered generalizable as those involved in the study, through interviews, have participated in the implementation of the APQP model.

In this study, a qualitative approach was employed, and an evaluation matrix was utilized to quantify the gaps identified within Volvo GTO PTP. Alternatively, a survey could have been conducted to collect opinions from respondents, thereby eliminating the time-consuming task of transcribing interviews. However, this alternative approach would have compromised the internal validity of the study, as respondents would have shaped their own understanding of the research questions. Lastly, it is important to recognize that this study is based on the organizational culture of a single company, which may differ from other companies implementing APQP and adhering to IATF 16949:2016. Consequently, variations in the application of this study are possible depending on the specific assumptions of each organization.

8.2 Contributions and Implications

This study makes a contribution by offering insights into the effective application of the APQP model by an OEM and its adherence to a supplier-specific quality standard. It is a rare opportunity for an OEM to achieve IATF 16949:2016, since it is a supplier specific standard. Hence, there are limited scientific research on the subject and this study contributes to a new way of thinking from a scientific perspective. Previous research has given limited attention to this area, underscoring the particular value of the findings presented in this study. Furthermore,

the existing literature on this topic is limited, and there is a lack of studies that combine the theoretical framework and gap analysis related to IATF 16949:2016.

In addition, the study emphasizes the importance of a QMS and the potential challenges organizations may face when implementing and effectively communicating the QMS. For Volvo GTO PTP in Skövde, this study establishes a practical connection between theoretical concepts and real-world applications of project models, thereby enabling the organization to enhance its operations. Moreover, this study developed a practical gap analysis process for identifying and addressing common gaps that may exist within manufacturing organizations. Finally, the study draws attention to critical activities that require recognition and management, assisting Volvo GTO PTP in implementing necessary changes to improve its quality preparation procedures.

8.3 Limitations and Future Research

The current study possesses several limitations that warrant consideration when interpreting its findings. Firstly, the selection of interviewees was constrained, potentially impacting the representativeness of the sample. Secondly, the validity and reliability of the results may be compromised by the respondents' interpretation of the matrix, which can be influenced by their overestimation of their knowledge. This phenomenon is particularly relevant in the lower section of the pyramid, which pertains to a new area being implemented in the organization's work processes. Additionally, it should be acknowledged that the investigation focuses on the specific context of the automotive industry, and there is a scarcity of literature resources available on this subject. Lastly, it should be noted that the implementation of the APQP model has evolved over the course of the project, resulting in variations in the level of experience with the model among the interviewees. These limitations should be taken into account when evaluating the study's findings.

To ensure the generalizability of the results across the entire organization, future research should aim to conduct a comprehensive study employing a statistically significant sample. Furthermore, it is advisable to assess the effectiveness of APQP in projects and identify any areas of ambiguity that require revision. Moreover, it is important to investigate the extent of leadership involvement necessary in the change process to determine the optimal starting point for implementing new QMS. While the report primarily focuses on how OEMs work with clauses from the IATF 16949:2016, it is also recommended to gain a deeper understanding of how suppliers implement IATF 16949:2016 to comprehend their work processes and requirements. Additionally, to enhance the understanding of the process of scaling up to an OEM level, it is advisable to examine how suppliers utilize IATF 16949:2016, including their requirements, the auditing process, change management, work processes, and terminology. Furthermore, similar research endeavors could utilize this study as a methodology for identifying and bridging gaps within an organization. The methodology comprises four steps: determining the desired future state, identifying the theoretical gap between the current and future state, identifying the practical gap, and finally, developing strategies to bridge the gap to attain the desired state.

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Appendix A. Interview structure

Date:
Duration:

Respondent:
Position in the organization:

Phase 1: Basic questions

A1. Is it okay to record the interview?
A2. What is your role in the organization?
A3. What do you know about ISO 9001?
A4. Have you heard of IATF 16949?
A5. The concept of quality preparation, what does it mean to you?

Phase 2: Quantitative part

This part of the interview involves the evaluation matrix in Appendix B, which is the new project model that may be implemented in the organization. Two follow-up questions to start a conversation with the respondent after they fill in the matrix is:

Where did you gain experience and knowledge in these areas?
What do you require to be able to take yourself to the next level in the area?

Phase 3: Qualitative part

Product development

The first level concerns Product development; it is about the handover of construction from GTT to GTO, which develops the manufacturing processes for developed products. In this area, the following questions were answered.

F1. How do you ensure the design is in place during the transition between GTT and GTO? And how do you communicate with GTT?
F2. When it comes to special properties for products, i.e. CC & SC requirements, how do you assess your knowledge of these requirements, and how would you describe the areas of use for these?

Process development

The area concerns the preparations to ensure quality processes. The following questions were answered:

F3. How do you work with preparing the manufacturing process, and how do you document this?
F4. What do you do with the information that PFMEA contributes to?

F5. How do you assess risk and set control strategies for this?
F6. How do you ensure that measurements are verified?
F7. How do you work to ensure that the assembler/operator gets the right conditions to do the right thing regarding their daily work? How do you know that the information for the assembler/operator is up to date and, above all, correct?

Validation
Validation concerns the level from when everything is in place to when the product is released. Following questions were answered:

F8. Are you aware of the approval of a new product and process for series production?
F9. The term PPAP, what does it mean to you? What are your experiences like?

Approval
The following questions concern the approval and guarantee to start serial production.

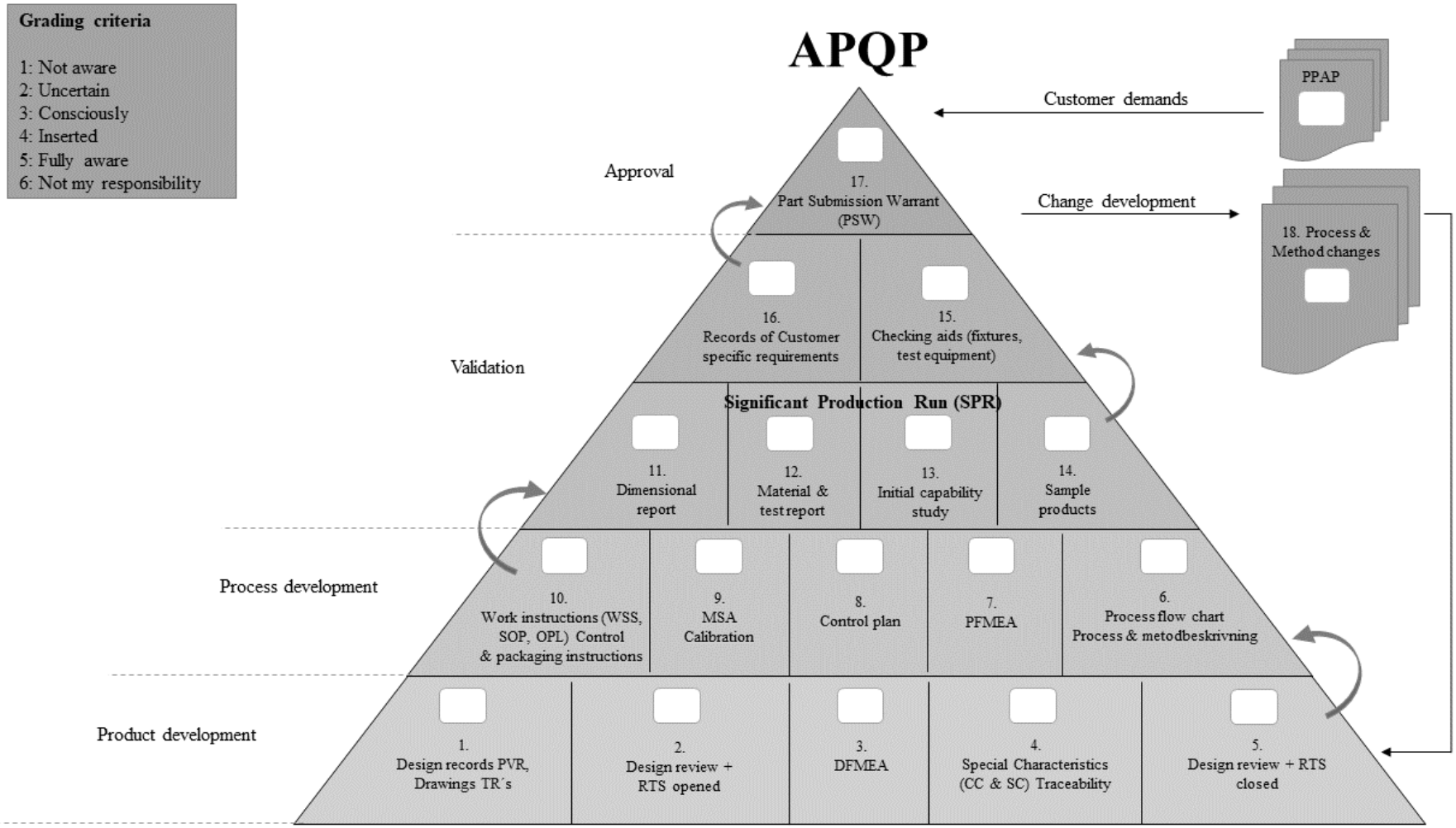
F10. What does the handover to production look like? What would documentation and archiving look like?

Change development
F11. How do you ensure process and method change?
F12. Are you aware of changes that have taken place in the past, and are these documented?

PPAP and documentation
The following questions are about PPAP and the importance of keeping documents current.

F13. How often do you revise documents for existing processes?
F14. Are you aware of the changes taking place in production?
F15. Why do you document? Because you have been told to do or is it to facilitate the work and upcoming projects

Appendix B. Evaluation matrix for interviews



Appendix C. Theoretical comparison tool

Figure C1 compares the Volvo GTO PTPs' current project model PSM that focuses on processes with the areas in the APQP model. Furthermore, the IATF clauses are compared in the tool inspired by the AIAGs gap analysis tool (AIAG, n.d.).

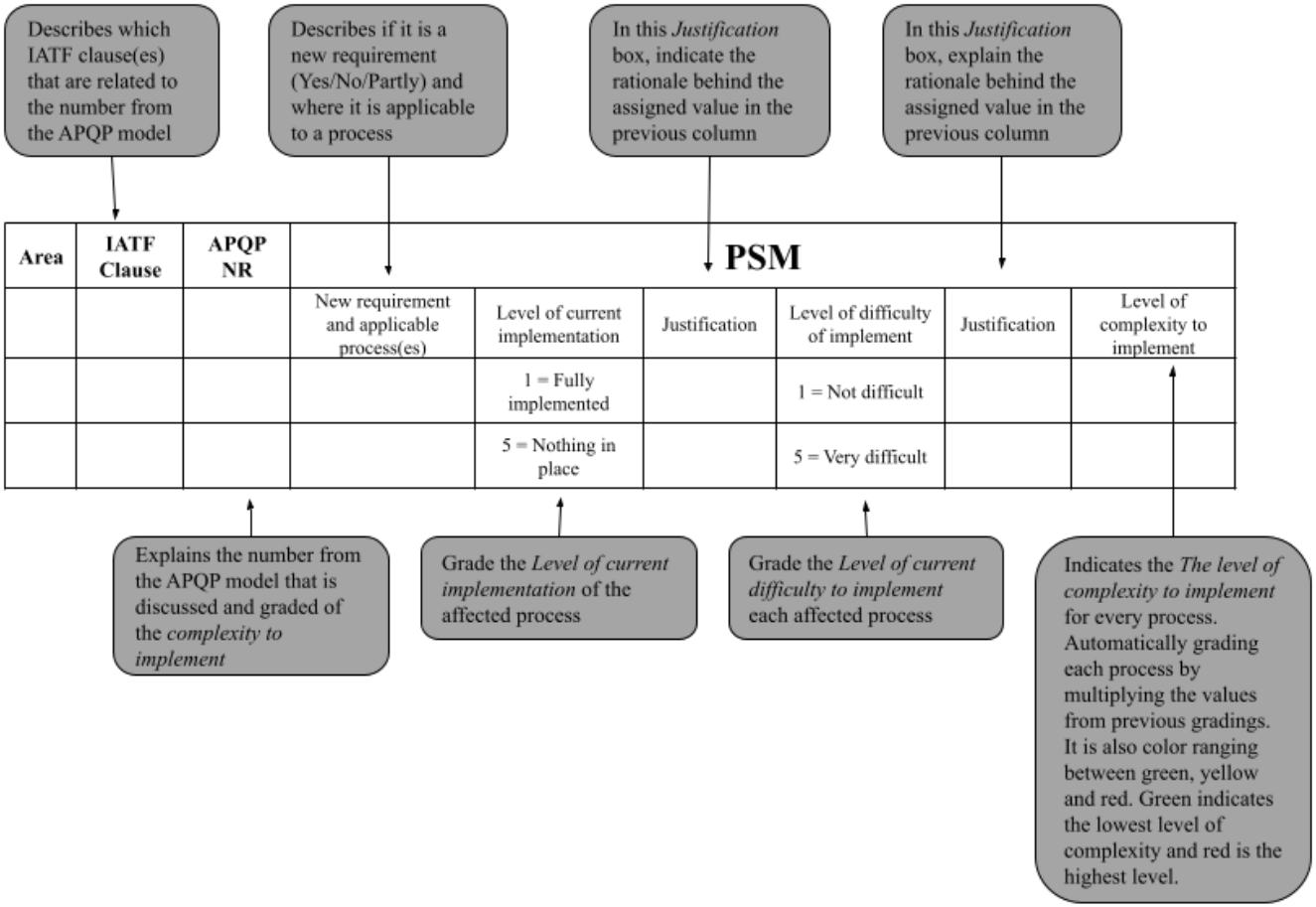


Figure C1. Explanation of the comparison between PSM and APQP.

Figure C2 compares the Volvo GTOs' current project model DVP which focuses on product development, with the APQP model's areas. Furthermore, the IATF clauses are compared in the tool inspired by the AIAGs gap analysis tool (AIAG, n.d.)

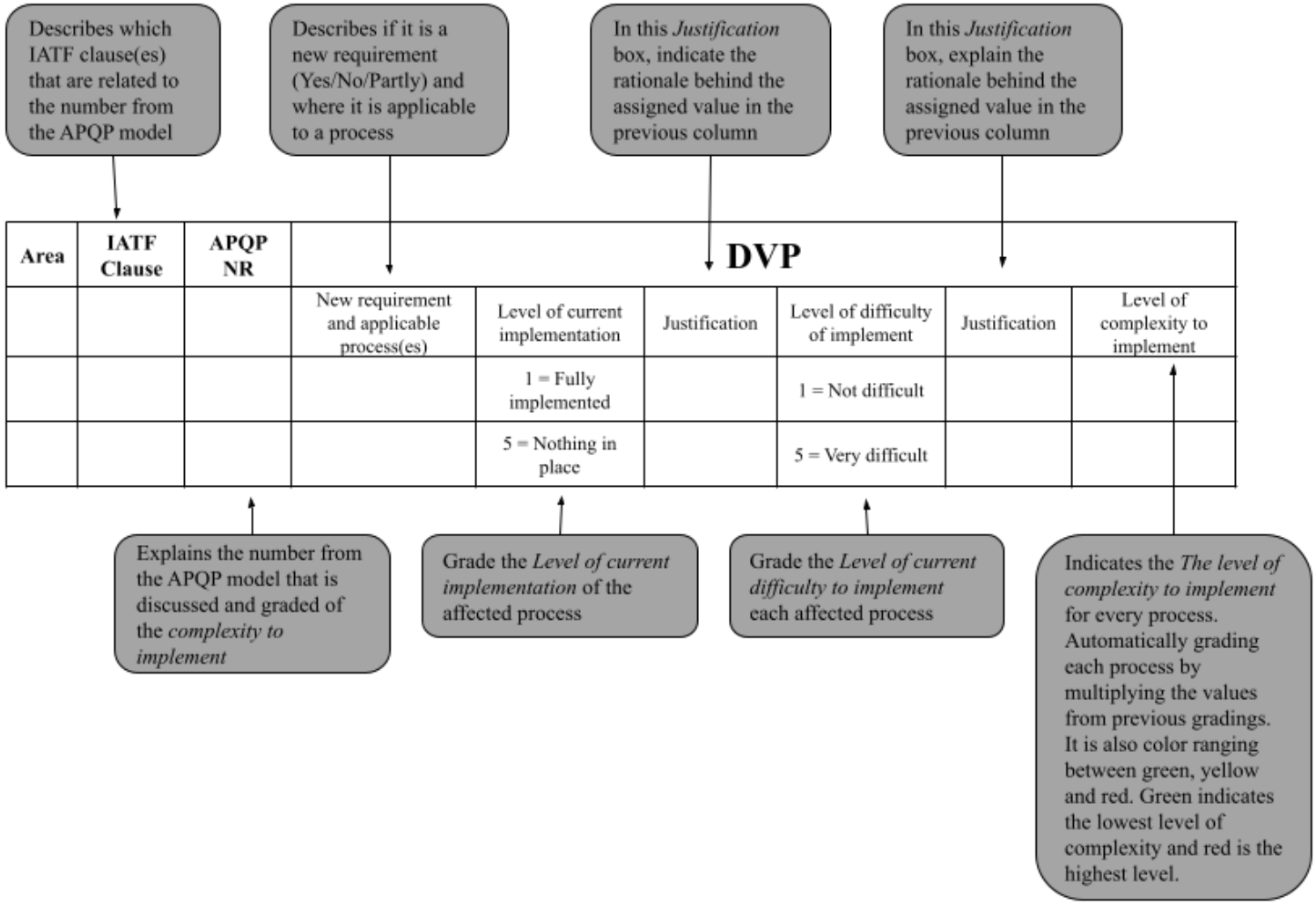
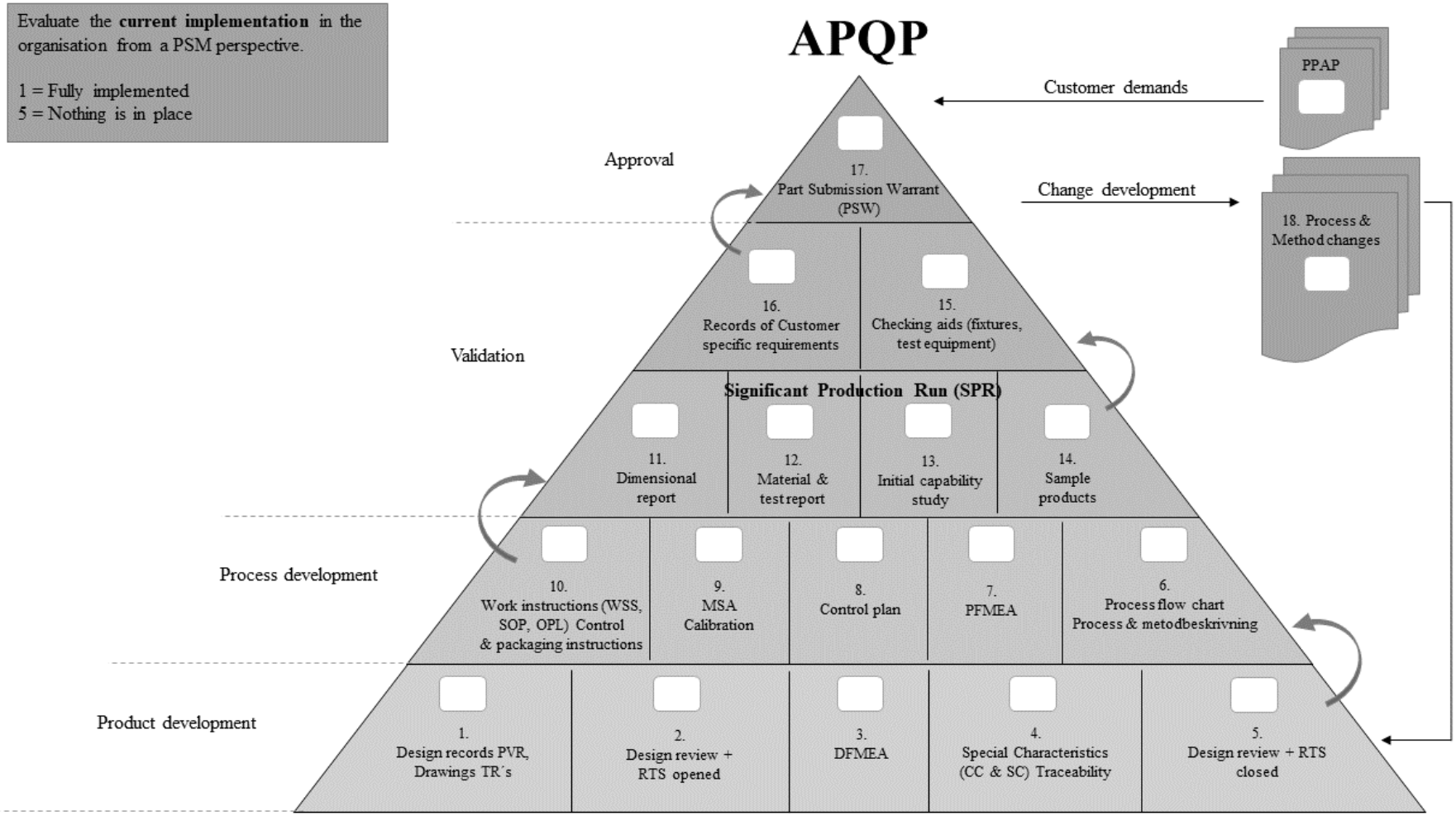
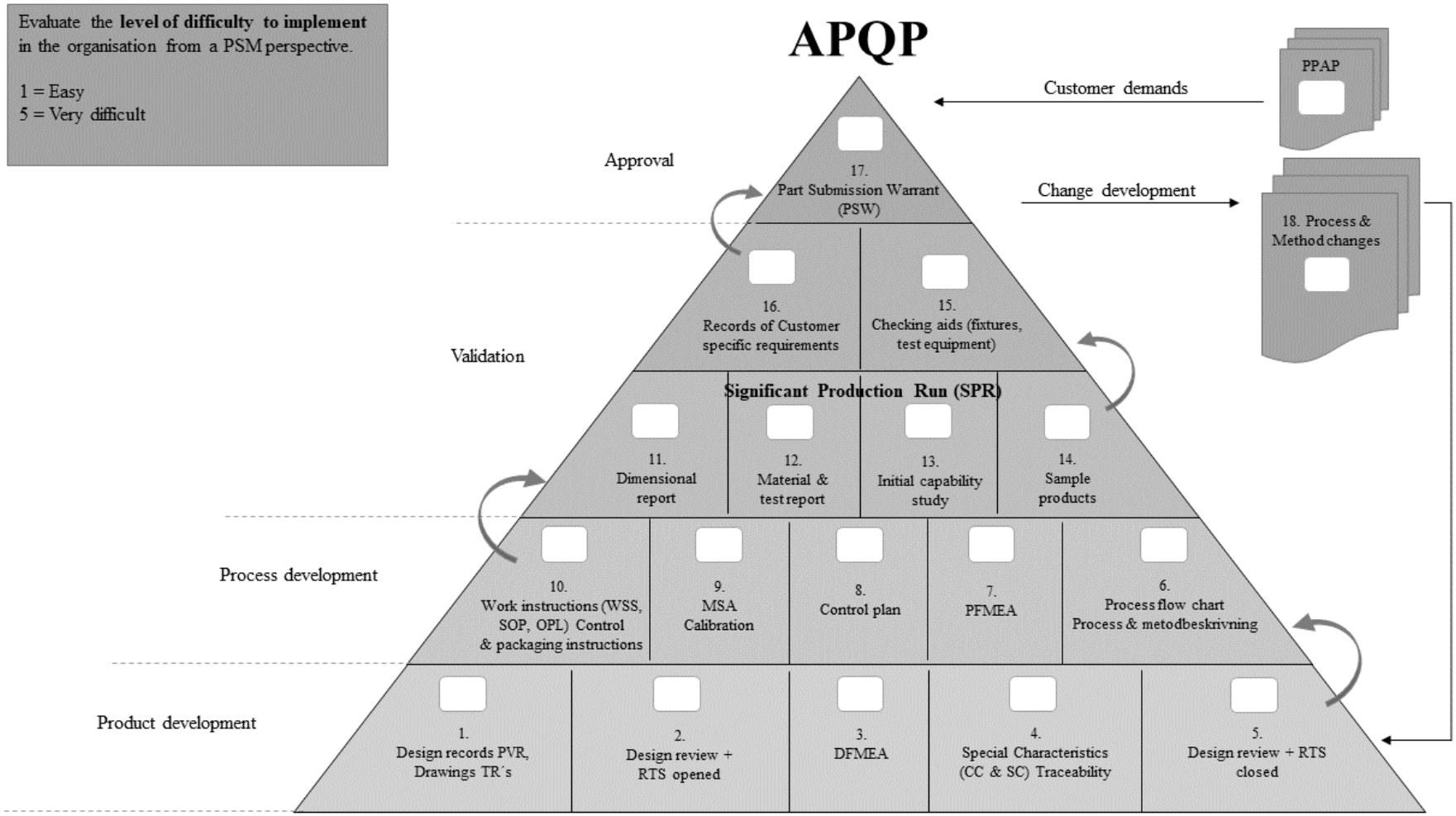


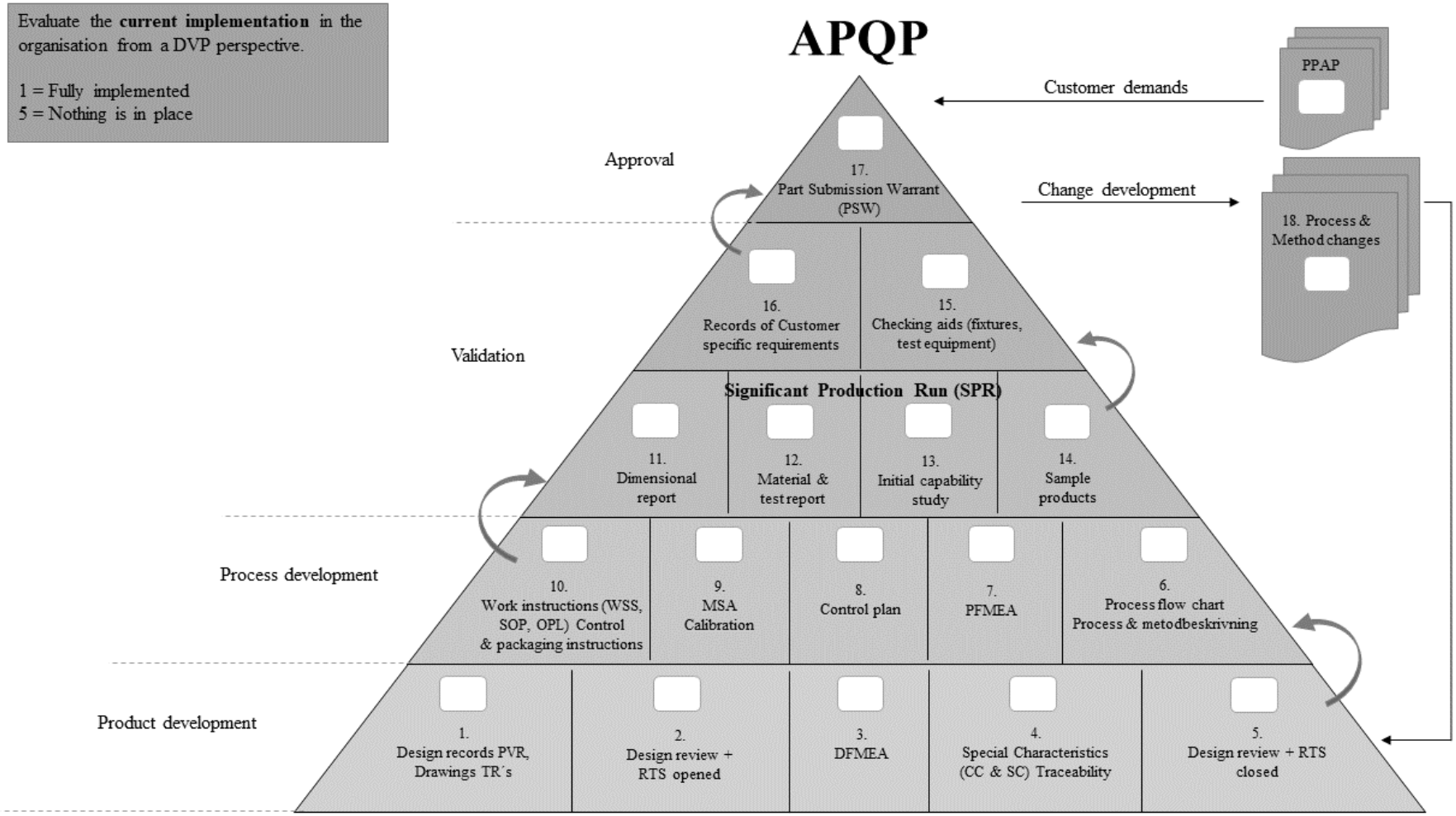
Figure C2. Explains the comparison between DVP and APQP.

Appendix D. Evaluation matrices between APQP and PSM



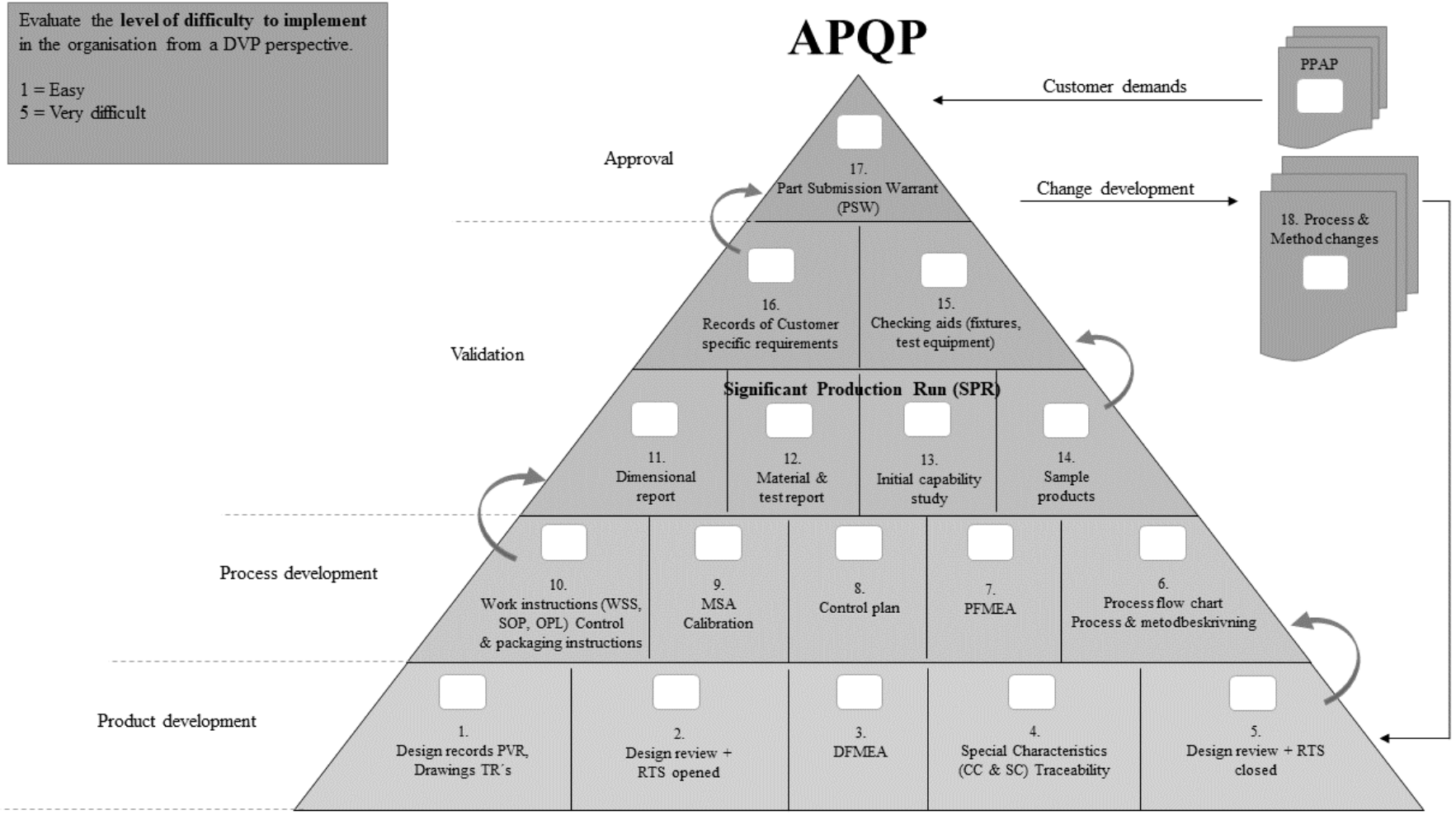

Evaluate the level of difficulty to implement in the organisation from a PSM perspective.
1 = Easy
5 = Very difficult
APQP
PPAP
Customer demands
Approval
17. Part Submission Warrant (PSW)
Change development
18. Process & Method changes
16. Records of Customer specific requirements
15. Checking aids (fixtures, test equipment)
Validation
Significant Production Run (SPR)
11. Dimensional report
12. Material & test report
13. Initial capability study
14. Sample products
Process development
10. Work instructions (WSS, SOP, OPL) Control & packaging instructions
9. MSA Calibration
8. Control plan
7. PFMEA
6. Process flow chart Process & metodbeskrivning
Product development
1. Design records PVR, Drawings TR´s
2. Design review + RTS opened
3. DFMEA
4. Special Characteristics (CC & SC) Traceability
5. Design review + RTS closed

Appendix E. Evaluation matrices between APQP and DVP



Evaluate the **level of difficulty to implement** in the organisation from a DVP perspective.

1 = Easy
5 = Very difficult



Appendix F. Compliance interviews

Compliance Supplier
Q1. What is the benefit of IATF 16949:2016?
Q2. Why did you choose to be certified with IATF 16949:2016?
Q3. How was the journey to be certified with IATF 16949:2016?

Compliance Industrial development
Q1. What is your role in the organization?
Q2. What do you know about ISO 9001?
Q3. Have you heard of IATF 16949?
Q4. The concept of quality preparation, what does it mean to you?
Q5. The term PPAP, what does it mean to you?
Q6. What is the future plan for Volvo GTO PTP in Skövde?
Q7. Challenges for the future?

Compliance MSA
Q1. How do you perform MSA?
Q2. What does that mean?
Q3. How do you choose what to measure?
Q4. Do you participate in the development of the control plan?
Q5. Are you an expert group that performs the measurements on the plant?
Q6 Could there be an expert group for each area of the pyramid to develop and verify the activities?
Q7. It has emerged that the MSA part is perceived as complicated and can be considered a critical point when it is to be implemented?
Q8. What do you experience as an MSA sufferer?'
Q9. Is it time consuming?
Q10. What is perceived as difficult on your part?

Compliance PSM
Q1. How well implemented are the steps in the APQP pyramid implemented in the PSM model?
Q2. How difficult will it be to implement those steps that are not fully implemented?

Compliance DVP
Q1. How well implemented are the steps in the APQP pyramid implemented in the DVP model?
Q2. How difficult will it be to implement those steps that are not fully implemented?

Compliance SQE
Q1. Can you briefly explain how you audit companies when investigating other suppliers?

Q2. What problems do you see other companies struggle with when they are IATF certified?
Q3. What are important areas you look at more when you audit companies?
Q4. Where do you see the SQE function entering the pyramid?
Q5. Where do you see flaws in this pyramid?
Q6. What should Volvo consider when working according to APQP and PPAP?
Q7. What does the communication look like with GTT, is there a forum where you discuss the needs for produced products?

Appendix G. Organizational analysis

The following tables (G1-G5) presents the thematic analysis. The tables consist of subthemes that groups quote from the interviews with respondents and the overall theme.

Table G1. Presents quotes from respondents correlated to the subtheme and theme of new products and processes.

Theme: New products and processes		
Respondent	**Quote**	**Subtheme**
R1	Our challenge is that we have been producing the same product for a very long time and we have small changes.	New products affect the day-to-day work of the organisation
R7	When it comes to what we have been producing for many years, we have an understanding of it. But when it comes to the new, we probably do not really know how it works.	
R8	We were pretty good at that once, but we lost some today.	
R9	New products do not have the correct networks	
R9	We currently have a very good structure on existing products	
R9	I think you lack an idea of how to build a quality management, ..., historically it has been copied and paste.	
R10	The area of quality preparation is something that we have noticed that we have actually lost over time.	
R14	When we tread new ground, ..., well then it can be a bit difficult	
R2	There is more focus now, an internal customer calls; we are colleagues, and to say that we have not finished, but we have prioritised this. It is a little more difficult when using an external client, but really it is the same requirements.	There are different requirements for internal and external customers
R8	I mean, when we deliver an engine to Tuve, we have no other requirement than that it be here on time. If you are unable to meet the requirements, you have to take care of them yourself.	
R8	Credibility issues	

Table G2. Presents quotes from respondents correlated to the subtheme and theme of the business works in silos.

Theme: The business works in silos		
Respondent	**Quote**	**Subtheme**
R10	Then everyone here should be much more out in the business as well, rather than sitting at their desks so that we are part of the system.	It is difficult to see the whole of the business
R15	It is very difficult to know for the head what the tail has done.	
R1	But the foundry is a process industry; they have completely different conditions.	The business is divided into different functions that affect the collaboration
R8	I usually talk about the fact that we have silos in our company.	
R10	Good to have the connection to today's production and tomorrow's production then, you would get the bridges much more naturally than something focusing on today and someone on tomorrow.	
R10	I do not always think that we neither respect each other nor provide the conditions for us to be fully successful. [GTX]	
R10	We are a team, but where you define the team is a bit unclear sometimes.	Unclear where responsibility for quality lies in the projects
R10	There is an image today that quality preparation makes quality	
R14	It is the producing unit that is responsible for the quality, but it still becomes ... unclear because it is the quality organization that is inside and supports and works with quality. It becomes a gray area.	

Table G3. Presents quotes from respondents correlated to the subtheme and theme of time-pressed projects.

Theme: Time-pressed projects		
Respondent	**Quote**	**Subtheme**
R2	Several projects are pressed for time.	The projects are perceived as time-pressed in order to be competitive
R4	Somewhere the delivery becomes so important that we get the product delivered rather than ensuring what it is we deliver.	
R7	But I think it depends on "time to market" as the focus now. It is the smartest thing that we come to the market at a special time.	
R7	You have already taken a lot of market share and we will come afterwards.	
R8	We already today, do not have the strength and resources to take care of everything.	
R4	[Projects] become very focused and very forced.	Projects skip steps in current project models
R7	In several projects now, we have skipped, ..., we go straight into development because we don not have time, and it will show.	
R8	It is when you work on projects that we tie everything together, and that is pretty good. But it is not always possible to get the knot fully together during running.	

Table G4. Presents quotes from respondents correlated to the subtheme and theme of the view of current project models DVP and PSM.

Theme: The view of current project models DVP and PSM		
Respondent	**Quote**	**Subtheme**
R5	DVP, it is a bit more bureaucratic, so a big administration page, cost as well... It is a risk register and everything.	There are advantages and disadvantages to current project models DVP and PSM
R5	PSM, not so much administration, quite simple, clear. You work with project directives and have gates.	
R10	I think DVP is sometimes a bit lame because it is theoretical.	
R12	The standalone PSM project works great.	The connection between DVP and PSM is unclear
R12	I would like not to work with both, but I would like to have a project management model that worked. Right now, the two models didn't work well together.	
R12	It is not very clear what deliveries I expect from the DVP project into the PSM project, and it is not at all clear whether the PSM project should deliver anything back to the project at all or not.	

Table G5. Presents quotes from respondents correlated to the subtheme and theme of familiarity with quality standards.

Theme: Familiarity with quality standards		
Respondent	**Quote**	**Subtheme**
R8	There is no value at all really in it.	The understanding for IATF 16949 varies
R8	I am not sure there is any value in it [getting certified], but we need to live up to the requirements.	
R8	We can take a lot of benefits from this in the form of improving our quality assurance processes, our production planning processes, and our industrial processes.	
R4	[IATF 16949] The way we talk about it here, I would say that it exists at certain levels at the MTM and MTS level, where there is control of what is needed, but I do not feel that it is spread throughout the organisation.	The understanding of quality standards is lacking
R4	[ISO 9001] Turn to how we talk about this within the walls and I would say nothing then.	
R5	[IATF 16949] Not so much now in my role.	
R6	[ISO 9001] But nothing I am aware of when I hear it referred to.	
R6	[IATF 16949] Not that I can recall. There are a lot of abbreviations and standards.	

Appendix H. Organizations' understanding

Table H1. Presents quotes from respondents correlated to the subtheme and theme of pyramid structure.

Theme: Pyramid structure		
Respondent	**Quote**	**Subtheme**
R1	Cause that is where it starts to be difficult cause if you have not done these previous steps, then it is quite difficult to do a control plan if you do not have a good FMEA for example.	The pyramid's flow makes it easier to see the whole picture of project
R4	Those who are well familiar with understanding the whole picture. But the majority see it as a one point event that has been decided to do.	
R6	We have followed the pyramid, maybe not always in the right order. We have worked some here and some there [referres to pyramid]. We do not get done instead, we come to a distance and then loop.	
R8	If we [reference group] been so formal, but that is the advantage with the APQP process that it becomes very formal. Plenty of these things we do, but we are not that formal in our steps.	
R14	That is how we do it more and more, and that is how we want to do it, but we are not 100% yet, absolutely, we are not fully there.	
R14	We have probably done very much of what the pyramids contain but we have done it as individual activities and have not seen the flow and understood how they connect to each other.	
R1	It is easy to cut corners.	Perception of the pyramid
R3	Now we do it from scratch, and that is what applies in production.	
R5	I enter quite early I have to say.	
R7	Looking at the old pyramid we work in the lower areas and have a good understanding of doing FMEA and such... the higher up in the process we get the more insecure we become I would say.	
R8	But there is an area that we have not, and now we have a lot of quality here, but we do not have any capacity.	
R12	Where is the project itself, procurement and installation of the equipment?	
R12	Late, way too late we come in.	
R12	Product development becomes an output to me, so I start here and say process development is the part I work almost 100%.	
R12	DFMEA and PFMEA are for me the central parts, and there I can say that we may not really get the connection between them.	
R12	I think that this is more machining specific. I think this is for machining, material and test reports sounds like a typical thing.	
R12	We have an arrow from process development to product development because if you develop the product without consideration to the process, it will not be able to be produced.	

Table H2. Presents quotes from respondents correlated to the subtheme and theme of managing and ensuring working methods.

Theme: Managing and ensuring working methods		
Respondent	**Quote**	**Subtheme**
R2	It is often our project leader that has the most contact with GTT and decides how we do it in the end.	Communication and collaboration with GTT vary within the organisation
R5	I think it is this usual that they are not good at the process.	
R6	It has been a bit unclear sometimes we have thought and the dialogue with GTT.	
R9	We understand that we need to review our drawings, and we want to have a handshake and we are well aware.	
R15	The dialogue and collaboration with GTT work well even in the early stages, and we in foundry specifically have a very close collaboration with the designers.	
R10	We can identify any number of risks if we do not take care of them ... that is not really that value-adding.	There are difficulties with risk management
R14	It is difficult to catch the unknown unknowns, meaning things we do not even know that the risk exists, these are hard to catch.	
R1	There are we not that strong, much depending on that we have high volumes and long experience.	The organisation is bad at conducting MSAs
R4	This has been a major issue in the foundry.	
R5	That does not happen... maybe knowledge and resources.	
R5	MSA I would assert that we are very bad at.	
R6	We have not done a lot of MSA yet, and here I am quite badly aware.	
R1	Have you really valued these objectively, or have you just driven your own race?	There are challenges with determining SC and CC demands
R2	Cylinder head has not been transfering the consequence class from 1-4 to CC and SC requirements.	
R3	Challenge here to get production interested.	
R5	This is something that needs to be built up. There are flaws in many. We move successively to this, more and more. ... But i think it is lacking.	
R6	GTT have determined a CC here. Then we work from that, why the is a CC and what it is that are critical that I have quite a bad understanding of.	
R6	I do not feel I would have wanted it at least. I understand the product way too bad to be able to take such decisions.	
R9	That, I have to say, is a really important role for MTS, when it comes here to the drawing stage, question what is the requirement we actually get in.	
R9	Then we understand what it means, then we have it really hard to achieve these requirements with traceability.	

Table H3. Presents quotes from respondents correlated to the subtheme and theme of responsibilities and ownership in the organization.

Theme: Responsibilities and ownership in the organisation		
Respondent	**Quote**	**Subtheme**
R4	Here, it becomes very difficult, because we are in a situation where we place orders and even install equipment, but we have not set a design review, they change all the time.	Difficult to take decision when the product is an adjusting target long into project
R4	The time we have means that we have to order stuff even though we have not set a pfmea and then it is even more important that those who work on this understand what affects each other when we buy, install and even produce products.	
R9	The product is a moving target very far into our projects.	
R15	It is very much based on being clear even at the beginning of the project what it is that you have to deliver for something, that it is very clear what it is that is expected, and that is also what controls how much of it you will need to submit to obtain that approval.	
R1	And on top of that you have a lot to do.	Organizations culture affect responsibility of product and processes
R1	And there are a lot of cultures in that so we do not fribble and these softer parts.	
R1	It takes ten seconds in the drawing program to put a one, and then you have your back free, but then you have not chellenged it.	
R2	They call from the assembly, and they can not assembly this and that. But we only check that they follow the drawing, so they have to solve it in that case.	
R3	It is our role to be zealous and that part and look for faults.	
R6	The question is if this topic has to affect me.	
R10	It is hard to say no. It is hard to stop.	
R9	I think we had good knowledge about that.	
R10	The responsibilty to produce goes over to production and then you can think whatever you want about the product. It is not done, well we have shaked hands.	
R10	Preparer who says that this I do not have time for. It is a part of your assignment.	
R6	It's so far ahead, so I haven't thought much about this, I don't think anyone else has either really... You dig where you stand.	Responsibility and ownership in the APQP model
R10	Think machinings reference group should be clear if they see that no, we do not have a control plan here.	
R12	Here I have really only worked with process validation and not with product validation, but we have built the product in our process. Then we sent the product away for testing, it's a black box for me.	
R12	Not that I know of, but in my world it is another organization that verifies the product.	
R12	It is mostly production technology, they together with the operators who do the most.	

Theme: Responsibilities and ownership in the organisation		
Respondent	**Quote**	**Subtheme**
R14	I can probably say already that I do not work actively in any of these parts, but that does not have to mean I am not aware of it.	Responsibility and ownership in the APQP model
R14	We know these and we are a part of it as a division even if I am not in it myself.	
R14	It is really our job to hold that handshake then as project manager, there is probably a little more to get there is my picture.	
R1	If we do figure out what to measure, I'm pretty sure we'll do it.	Responsibility and understanding of MSA are unclear
R1	After all, we have good, quite good competence in our lab rooms and measuring rooms, as long as we know what to look for, we will do it.	
R1	But I don't think so, if we have decided to measure a certain measure with a certain frequency, then we have quite strong routines and routines to get it done.	
R2	Technology is usually responsible, but quality is included, we usually always get to be there and see what is being done.	
R3	I don't know if I'm honest ... I hope the experts are aware of that.	
R3	I haven't worked with MSA, but I know pretty well what it is... We have a couple of guys who work with that. They are specialists.	
R11	And we have very talented production technicians there.	

Table H4. Presents quotes from respondents correlated to the subtheme and theme of organizational lack of knowledge.

Theme: Organisational lack of knowledge		
Respondent	**Quote**	**Subtheme**
R3	No, it is very flawed. We do have a process change log like this, but the quality of it is not the best.	Poor structure of documentation on product and process changes
R5	It is not easy to find in them, not easy to find in all. It's a bit of detective work.	
R6	How it is ensured that you really do this step again, I don't know if there is any particular one.	
R6	But competence is good, of course, to understand that if we have made a change that affects the product or that affects the equipment, then we kind of need to go back to the FMEA and think about what consequences it might have. I feel that it was not always done in the processing.	
R2	Then we have 15 here checking aids fixtures, test equipment. Not really sure what is meant here... It's probably more technology that runs and sounds like it.	There is a lack of knowledge regarding areas in the APQP model
R2	I'm probably unsure there.	
R3	In the past it has been small projects, but it has sat in hindsight and filled in the poor thing and it won't be right because you have the facts in hand.	
R4	DFMEA, I think we're a little unsure there. Our focus ends up a lot on PFMEA, then we are involved in doing design for manufacturing and so on, but we are, I think we lose a bit there.	
R6	Have heard the term PPAP. Now we deliver to an external customer, and need to make a PPAP. Then I'm not particularly familiar with what that means.	
R7	Then it's so different, we have quite a few new ones in my group, so we're still developing.	
R7	Design review, I can't really answer that.	
R8	When a full-time exam, you have to pass the right quality in the given time then, but that I think you need more clarity. It is easy for us to move on before we have tuned the process to handle the right capacity as well.	
R8	I cannot answer that question. I really do not know.	
R8	DFMEAs, I'm a little unsure of how much we are involved.	
R9	Records of customer-specific requirements what do we mean by it then?	
R10	The operators removed the plastic and the plugs because they thought it was much faster to assemble. We pay a lot for them and there was a reason.	
R11	I have no idea what that is.	
R1	After all, we want all the material we buy that comes in to have PPAP on it, we do, but we are not that familiar with the actual PPAP process ourselves yet.	There is a lack of knowledge regarding PPAP
R4	But I can say that I don't even know if the word PPAP is used in foundry..	
R9	It is some kind of project plan to secure the product ... I am a little unsure about that.	
R11	I don't really know much.	

Appendix I. Bridging gaps

Table I1. Presents quotes from respondents correlated to the subtheme and theme of clear involvement of different functions in the APQP model.

Theme: Clear involvement of different functions in the APQP model		
Respondent	**Quote**	**Subtheme**
R1	The projects that turn out well are where you have had strong teams.	Early involvement in the APQP model
R1	We have a lot of processes over the years, as far as I know, but the important thing is to boil it down to having personal collaborations, that you work together in everyday life [GTT & GTO].	
R2	Must join as early as possible.	
R3	It is essential that you have a dialogue and that you have physical meetings and not team meetings, that GTT comes to GTO or vice versa.	
R3	I want to have a collaboration right from the start.	
R3	If we have a good dialogue, then we have great conditions to be able to succeed.	
R5	Yes, but it is more GTT's area that we want to get into the concept as early as possible.	
R9	I do not think it can be too soon [GTT & GTO].	
R2	Project managers invite quality as early as possible, in the same way that they are not invited when you have to do the FMEA, but you may be involved from the beginning.	Involve the quality function in project
R5	We have received support in this work and it is required because there are many templates and stuff you must keep track of. Then you need some form of administrative help.	
R5	You need to have a quality preparer in the projects which do this, who has competence and administration skills [pyramid].	
R6	We have been told from several quarters within the quality organisation that we need a common thread through this document [the pyramid].	
R7	That you close up and [quality] perhaps becomes an even clearer part of the team's deliveries, as well as clarifying that collaboration.	
R12	Yes, it would be exciting to get more into the chosen project management model and get quality preparation more clearly into the points we have [PPAP].	
R1	Should do it ourselves and so that it becomes something you yourself have been involved in, then you learn better [SOP].	Involve and train the organisation in APQP
R4	I think it is good to spread the understanding that a person should do something and not just see it as a burden. You also have to understand the consensus of it.	
R6	It is probably good that all operators or in production understand what this is and when to use it [the pyramid].	
R8	We must not build the silo stronger, ..., but in the end, the important thing is that we have a PPAP on the complete product that leaves Skövde.	
R8	To say that from today, it is APQP 100% in all projects, then no projects will fall out, I think [Stepwise implementation].	
R10	It is quite fun when we go into production. There is quite a lot of work behind it.	
R10	Then it is about reaching out to all those who are actually affected.	

Table I2. Presents quotes from respondents correlated to the subtheme and theme of difficulties for activities in the APQP model.

Theme: Difficulties for activities in the APQP model		
Respondent	**Quote**	**Subtheme**
R6	We need to understand if I make a change then after the change, I have to redo these steps [Pyramid]	Lack of knowledge about the structure of the pyramid
R10	Yellow status means you have an action plan.. It is red if you do not have an action plan.	
R10	It is probably the same there. Who owns the method? It has been an interesting question over time.	
R12	Actually, there is no clear place where we build the line ourselves. It is not very clear.	
R15	Actually, when you make this process change, you must go back and see what we will affect in the flow.	
R1	If there is not a good DFMEA, well, then it is difficult, because it becomes a sequence that you look at these [pyramid] activities.	Difficulties in designing and using DFMEA and PFMEA
R1	It is challenging to do a good FMEA, but you know the theory. It is essential to break it down and "keep it simple" because it can quickly become so large in our complex operations.	
R9	We have a bit of a problem. I thought that there are many people today who are expected to do PFMEA or be inside them so that we evaluate things very poorly.	
R10	We should have that in all departments. Every production manager should ensure that I have my PFMEA.	
R15	You fill in points so that you do not think that the FMEA is a one-time product but is actually a living document.	

Table I3. Presents quotes from respondents correlated to the subtheme and theme of opportunities in the APQP model.

Theme: Opportunities in the APQP model		
Respondent	**Quote**	**Subtheme**
R4	If we do not get audited so that someone actually requests like we go in and look, "now we have done this", can you show how we follow this way of working?	Need for demand for deliveries in the APQP model
R4	If you do not get audited, people take the shortest route, ignore it. Yes back to demand.	
R8	Today, no one among us asks the clever question(s) to ourselves.	
R8	That is the strength of it, and if you go to a supplier, they train on this pyramid daily because they introduce new products all the time.	
R9	If you do it rarely, you will not get good at it.	
R10	Customer perspective.	
R10	You get help from someone who comes from outside and looks at your business. It can be correct, it does not have to be, but then you can deal with it.	
R7	Now, we design the product parallel to developing the process because the schedule is so compressed. I feel that we are involved to a great extent.	Clarify the interconnection between product and process development
R8	So the more we want to stick to a flow, the more critical it is that product development and process flows sit together.	
R12	You must have feedback from process development to product development. It is best if these two are parallel.	
R4	There is a lack of knowledge regarding areas in the APQP model	Possibility of developed methods in the APQP model.
R5	But if you see this flying and you want it, then it must be. It cannot be on its own, but it should probably be integrated into PSM and DVP.	
R8	Well, the pyramid is built on this for some reason the more energy the wider the pyramid is at the base the more secure the top will be.	
R12	It would have been much better and when I lead a project and just a clear model would have been very much better simply	
R12	It was a more interactive process, it was a bit more scrum-like at the time when you developed it.	

Appendix J. Correlations between analysis