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Change Request Execution Guideline for R&D

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Preface

Since I have been working in project management for more than seven years, I have always wondered if learning by doing can get me somewhere. I had my doubts as my bachelor's study was purely technical. I believe that the gap will always exist and learning will never stop. I'm very proud of what I have achieved and learned during this study and the program, it has never been easy. However, it was a great pleasure.

I would like to thank all my colleagues in this program for helping along the way, and for helping to bring up new ideas, different perspectives, and critical feedback. I thank my core team for helping me during the study.

Special thanks to my instructor, Dr. Thomas Rohweder for the support, guidance, and encouragement, some of his words and phrases so to say will never be forgotten. I would like to thank M.A. Sonja Holappa for her great support with the thesis writing, and presentations, my emails, presentations, and future writings will always be influenced by her constructive feedback and comments.

I express my gratitude to all the lecturers who have made valuable contributions to this program. Each of you has enriched my knowledge in some way.

Last but not least, thanks to my beloved wife for her encouragement and patience throughout this journey.
Thank you, mother, father, and sisters to whom I always dedicate my achievements for always being there. To my son for bringing endless interruptions during my studying time.

I'm thankful for all the blessings in my life.

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Abstract

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The case company has been utilizing the change request approach to formally manage internal and external requests and demands to alter a product, a process, or a service. In the R&D section, despite the highly skilled team, the efficiency of the change requests has been questioned. This is due to the time consumed to define the testing scope, and test targets for various types of alterations such as design changes, or main components changes. Which directly impacts the team utilization and influences the cost of engineering internally and externally. Accordingly, This thesis aims to develop a comprehensive guideline to enhance the change request execution process for the R&D department of the case company.

The applied research approach is applied to investigate the current business problems that necessitate an urgent resolution or outcome to be delivered to managers and stakeholders. This study utilized qualitative data methods for data collection. The research design involves four main stages with three data sets starting with the current state analysis that provides a summary of the current process strengths and weaknesses. The primary data sources utilized in this thesis comprise interviews with key stakeholders, workshops, and internal materials from the case company. Followed by the conceptual framework to identify potential improvement ideas based on the current state analysis output and the literature review.

This leads to a co-created initial change request execution guideline proposal aiming to streamline the change request execution process. The final guideline is validated and feedbacked, providing a more comprehensive understanding of the process.

Keywords: Change Request, Change request execution process, Improve change request process

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Abbreviations

CF	Conceptual Framework
CR	Change request
CSA	Current State Analysis
DFMEA	Design Failure Mode and Effective Analysis
PFMEA	Process Failure Mode and Effective Analysis
HAZOP	Hazard and Operability Study
KPIs	Key Performance Indexes
MoM	Minutes of Meeting
PDM	Product Data Management
PPAP	Process Part Approval Process
RCM	Reliability-Centered Maintenance
SCR	Self Certification Repository
WSJF	Weighted Shortest Job First

1 Introduction

Research and development departments are the first defense line of the company when it comes to design problems or potential future problems, besides working on innovations and performance improvement topics.

The lessons learned concept in change management involves systematically capturing, analyzing, and applying insights gained from previous experiences. It includes documenting a project positive and negative aspects, reflecting on successes and challenges, and distilling valuable insights. These insights are then formalized, communicated to relevant stakeholders, also used to create a procedure on how to handle such changes effectively. The goal is to promote continuous improvement, enhance decision-making, and avoid repeating mistakes. Common procedures contribute to a dynamic and adaptable organizational culture, supporting risk management, knowledge transfer, and the overall improvement of organizational performance.

The complexity of new technologies, how and where they are used, makes solutions very complex and challenging to achieve, thus defining the solution path or a guideline is the key to more smooth and efficient management of changes.

1.1 Business Context of the Case Company

The case company is a global leader in the industry, committing to pioneering innovation and reliability of its products. Its century-long legacy aligns with its vision and mission mainly focusing on the best ways for people to flow and make urban living more convenient and sustainable.

The case company R&D strives toward ongoing innovations, maintaining the position of its products in the market. Adding to that, the environmental responsibility by focus on green building certifications and eco-friendly materials. The case company optimizes movement in buildings, enhancing efficiency, safety, and comfort. Smart solutions, such as the Destination control system, minimize wait times, maximizing the user experience.

In addition, it tailors solutions to project requirements through collaborations with architects, builders, and facility managers. The result is seamless integration and optimal performance throughout a building's lifecycle.

1.2 Business Challenge, Objective, and Outcome

While actively engaged in innovation and technological advancements, the R&D department of the case company battles with persistent challenges related to site issues and the modification of existing product design, component material, or suppliers. One major challenge is the substantial amount of time needed to establish the testing schedule and the scope for modifications in design or components, even when working with a highly skilled team.

The year 2024 brings new difficulties, emphasizing the benefit of alternative solutions for main and sub-components while preserving or lowering costs. Accordingly, the management decided to target H1 2024 for the CR execution process improvement.

The objective of this thesis is to establish a comprehensive CR execution guideline specifically tailored for the R&D department. This guideline aims to

address and streamline the process of defining testing parameters and expediting decision-making and implementation.

The anticipated outcome is the creation of a well-defined CR execution guideline for the R&D department.

1.3 Scope and Outline of Thesis Report

The thesis focuses on the CRs related to new design, material, or supplier changes. The CRs related to new products and new product implementations are out of the scope of the study.

This project is divided into seven sections. The initial section introduces the project topic, followed by Section 2, which defines the project plan by outlining the research approach utilized, and describes the research design, and the data collection plan. Section 3 illustrates the current state of the process at the case company, summarizing findings from the analysis. Following the current state analysis, Section 4 defines the literature review and conceptual framework of the study. Section 5 introduces the outcomes from Sections 3 and 4 as initial proposals for the CR execution guideline in projects.

This guideline undergoes validation in Section 6, with the aid of the feedback collected from stakeholders and process owners. The concluding section offers executive summaries, proposals for the next steps, and a self-evaluation of the thesis project credibility.

Building on the foundational concepts introduced in Section 1, Section 2 explores the specific methodologies and research design utilized in this study. This includes a detailed description of the research approach, data collection methods, and the analytical framework employed to examine the CR execution processes within the R&D department.

2 Project Plan

This section describes the project plan starting with the selected research approach to serve the purpose of this project to develop a guideline for the CR execution process.

In addition, this section outlines the research design and explains different data sets including the expected outcome of each data set. So, it is clear why each data set collection was undertaken.

Then the last section describes the data plan or how the data sets were collected, the source of the data and information, Informants for each data set along with the timeframe & the expected outcome.

2.1 Research Approach

Several approaches exist for undertaking a research project based on the purpose and the context.

As advanced by Saunders et al., one extreme of the continuum involves research purely aimed at understanding business processes and outcomes, often conducted in universities with an academic focus and minimal practical relevance. This type of research is termed basic or pure research. The other approach is defined as an applied research approach that is relevant to subject matter experts such as managers, team leaders, and executives for solving an urgent business problem and results in a solution to this problem. (Saunders et al., 2007: 7.)

2.1.1 Applied Research Approach

The applied research approach is a systematic and scientific inquiry that aims to address practical problems, answer specific questions, or provide solutions to real-world issues.

Accordingly, this approach was utilized for this project as it is characterized by its practical orientation, seeking to generate knowledge with immediate relevance and application in practical settings.

The purpose of applied research is to understand and help solve practical problems. This typically includes problems associated with whether and how to undertake new programs or modify existing programs and includes questions regarding design, resources, planning, development, implementation, and improvement. In other words, a practical solution is required for the existing business problem. However, the solution requires merging the practical development with the theoretical research. (Kananen 2013: 20-21.)

2.1.2 Applied Action Research Approach

Action research is a cooperative method of inquiry or investigation that offers a methodical approach to resolving a particular problem. As it offers a method to gain a better understanding of the situation and develop efficient solutions to the challenges at hand. (Stringer, 2014: 8-9.)

2.2 Research Design

This section shows the research design and defines different stages of the project.

Triangulated data concept was considered during data collection which means multiple data sources were used to gain a more comprehensive and reliable understanding of the phenomenon under study (Bryman 2012: 392).

The research design consists of 4 main stages with 3 data sets:

1. The CSA of the CR execution process. The pros and cons, and an informative summary of the strengths and weaknesses of the current process were the main outcomes.
   Also, the CF was defined by the preliminary number of ideas based on the CSA performed and defined as data set 1.
2. Potential improvement ideas were identified after concluding the first stage where these ideas are considered significant and should be included in subsequent design stages. This emphasizes the importance of using insights from the analysis phase to inform and guide future actions and decision-making.
3. Based on the data collected, the initial CR execution guideline was implemented, where many improvements to the current process were defined and this outcome was data set 2.

The last stage was the feedback and validation of the initially proposed guideline. The output is the final proposed CR execution guideline and was described as data set 3.

Figure 1 below shows the research design and depicts the different data sets content and expected outcome.

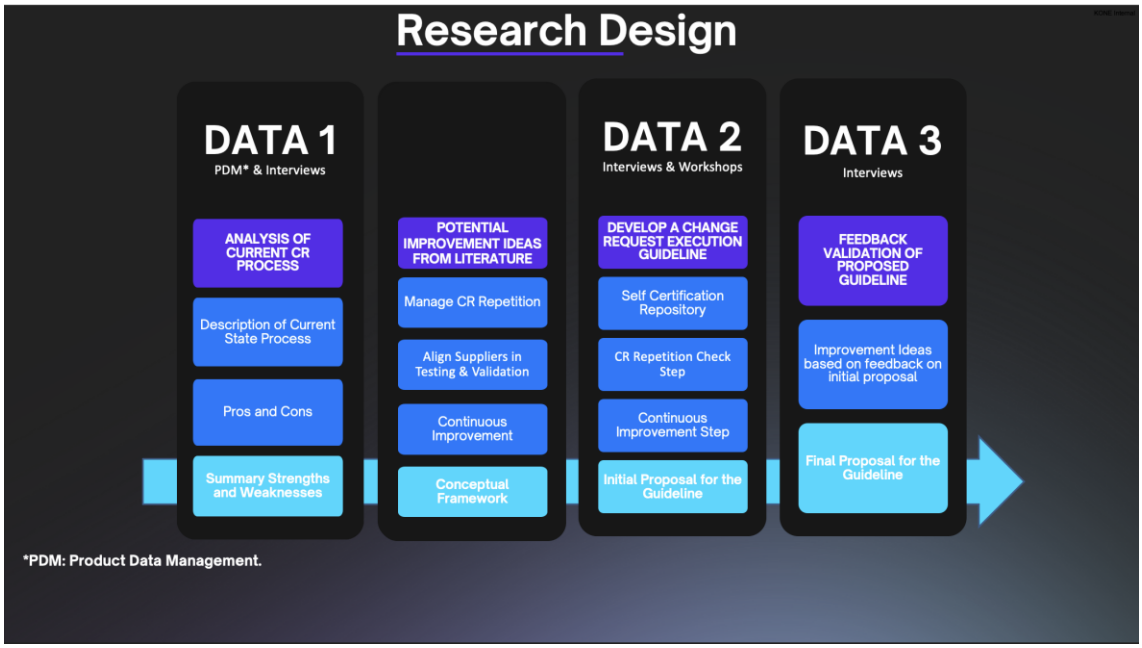

Figure 1. Research design.

There are four main stages in the above-mentioned order based on the nature of the project. Data for the CSA was collected by conducting dedicated interviews with the stakeholders and product owners to gain an idea concerning the current process and the recommended solution from their point of view. In addition, a workshop was arranged for this purpose to obtain more data.

2.3 Data Plan

In this section, the data collection plan was set for each of the three research design stages.

The plan for data set 1 involved the definition of the current state analysis of the existing CR execution process from the system perspective, which was the product data management system, that is currently responsible for managing the CR execution process. It was undertaken by the extraction of data from the

system to define the scope of CRs, the complexity of the topics, and the duration of the execution.

In addition to that, it shows the plan set for execution and what kind of data is used for the verification and validation of the testing processes including the tools used, historical data, and some fixing proposals.

The plan included the people to inform and the timeframe for the data collection activities.

The plan for data set 2 has included ideas collected from stakeholder interviews and the workshop held to secure a high level of data collection. The plan for data set 3 involved the collection of improved ideas based on the feedback from stakeholders regarding the initially proposed guideline.

Figure 2. below shows the data plan and emphasizes the execution process for data collection.

Data Plan

	CONTENT	SOURCE	INFORMANT	TIMING	OUTCOME
DATA 1 ANALYSIS OF CURRENT CR* EXECUTION PROCESS	• Description of Current State Process • Pros and Cons.	• Product Data Management. • Interviews • Workshop • External Suppliers	• Product Owners • Team Leaders	Jan	• Current process overview • Strengths and Weaknesses.
DATA 2 DEVELOP A CR* EXECUTION GUIDELINE	• Self Certification Repository • CR Repetition Check • Cont. Improv. Step	• Interviews with Stakeholders. • Workshop.	• Product Owners • Team leaders. • External Suppliers	Mar	• Initial proposal for developed Guideline.
DATA 3 GUIDELINE VALIDATION & FEEDBACK	• Improvement Ideas based on feedback on initial proposal.	• Meetings with Stakeholders.	• Product Owners • Team leaders.	April	• Final proposal for improved Guideline.

Figure 2. Data plan.

Qualitative data collection strategies such as interviews and workshops were employed with relevant stakeholders and supporting functions to pinpoint the challenges faced by the company and tailor recommendations accordingly. The goal of using qualitative methods was to gain a deep understanding of how change is managed within the organization, ensuring the derived insights are detailed and practical.

Figure 2 describes the informants for the data sets for data collection to be the product owners for different products and team leaders impacted directly by the improvements in the CR execution process.

Planned Face-to-face and remote Interviews were conducted with stakeholders with the aid of pre-defined questions sent to interviewees three weeks before the interview time.

This section concludes the Project Plan. The next section goes over the Current State Analysis, which was done in-depth at the case company to discover the main problems with the current CR execution process.

3 Current Analysis of Change Request Execution Process

This section analyzes the change request process at the case company. It identifies patterns, problems, and factors that influence the process. This section starts with an overview of the process using available data. It then provides a detailed description and illustration of the process. Finally, it summarizes the findings by presenting the strengths and weaknesses of the current change request process.

3.1 Overview of How the Data Stage Was Undertaken

The CSA stage aimed to assess the current CR execution process for the case company. The objective of this study was to provide a guideline for improving the CR execution process to enhance the efficiency of the process and cost-effectiveness. A diverse team participated in face-to-face and remote individual meetings for a supplier quality engineer and a supplier team lead respectively. In addition to that, a workshop with the R&D core team:

- One mechanical expert
- One electric expert
- One electronic expert
- Two project leads
- One product owner

The selection of the core team for this study was crucial to ensure data quality and avoid obtaining misleading or low-quality data. The interview questions, workshop agenda/questions, and study purpose were communicated three weeks before the planned dates to ensure readiness and preparation.

The questions were formulated to be concise, clear, and simple to obtain understandable answers. The attendees were informed of the study purpose and how their data would be used. The findings from this stage inform the recommendations for improvement in subsequent stages.

The first data source was the PDM, which outlines the CR execution process and includes the current process guideline for step-by-step CR execution instructions which help to provide a clear understanding of the typical flow of the process and how CRs are normally executed.

The second source involves conducting interviews and workshops with team members, as mentioned earlier. This provides insight into how the execution process was practically executed and gathers feedback from the team.

The preliminary outcome of this analysis has identified the improvement opportunities, despite acknowledging that the process is solid, safe to follow, and ensures positive outcomes.

3.2 Current State Process Definition

This section outlines the current state of the CR execution process within the case company, based on the data collected.

The case company has adhered to a robust CR execution process established 30 years ago. Since then, continuous improvements have been made to ensure the success of technical testing and validation activities and to meet satisfaction levels. However, in prioritizing critical aspects such as engineering hours and time consumption, opportunities to streamline the process may have been overlooked, along with lessons learned from past experiences.

The PDM system serves as a versatile platform with various functions, including document control, product configuration, and change management. This platform facilitated the study by providing clear flow diagrams of the existing process, which were referenced during the interviews to assess the practical execution of the process.

Figure 3 below illustrates the main three types of CR flow diagrams. A simplified process flow is presented showing a gate check for the team capacity as a decision-making step to proceed with executing the change request or not. This shows the influence of the team utilization on the number of CRs to be committed for execution within a quarter.

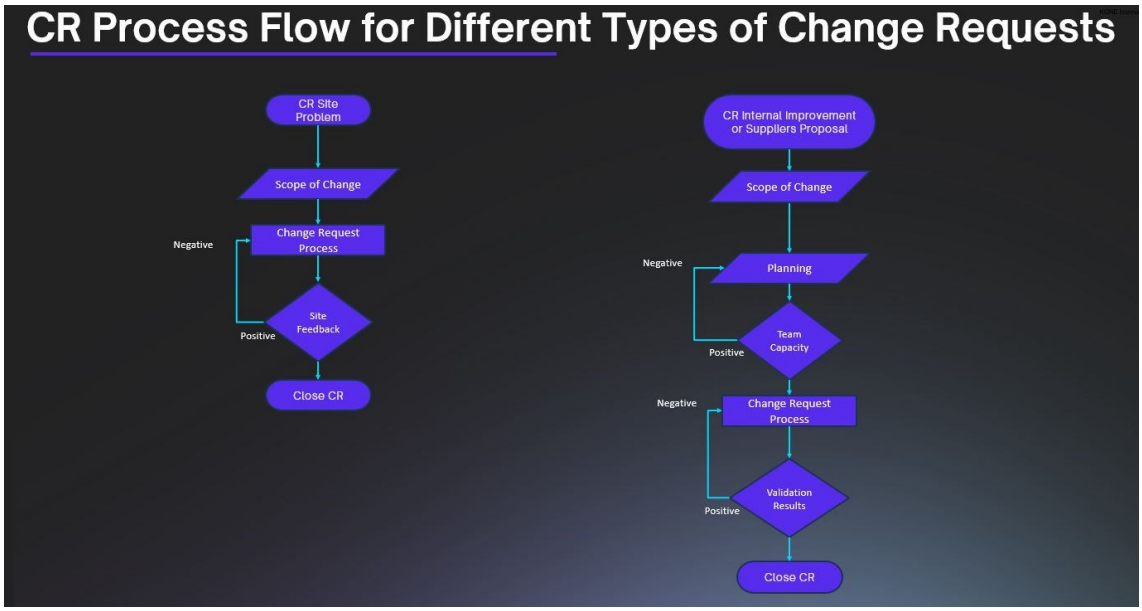

Figure 3. Process flow for different types of change requests.

The main difference between the three types is the priority and urgency of site problems where corrective actions are checked and tested on-site after performing the possible validations and assurance activities. The CR associated with a CR problem is normally monitored directly by the quality team since it affects the quality KPIs and requires direct interference during and after clearing the problem.

Figure 4 offers a detailed view of the CR execution process, from request initiation to closure.

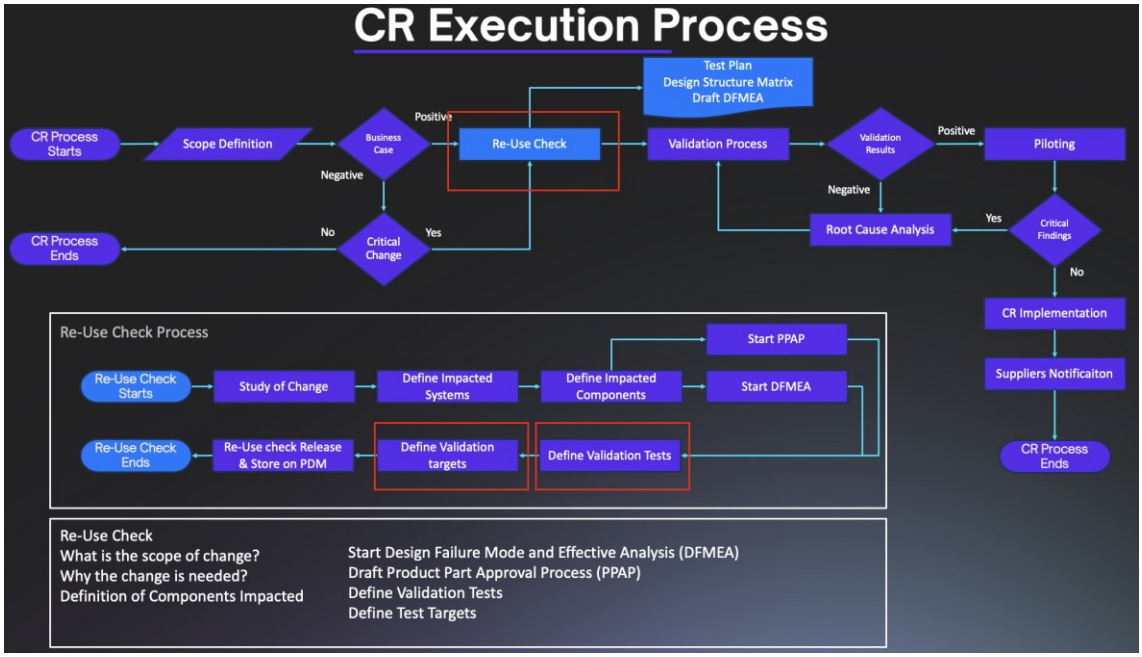

Figure 4. Change request execution process Flow Diagram.

Figure 4 provides a detailed description of the CR process, outlining the distinctions between each step and highlighting the main objectives for each action. For instance, the re-use check" and PPAP steps define the scope of the change request and emphasize its purpose. It also depicts how the CR process can be defined starting from the stage of scope definition. This is the point where the supplier or the CR initiator describes the scope of the change proposed.

The process then moves to a critical decision-making gateway where the business case is evaluated. Here, it is noted that management gets to decide to proceed with a change despite a negative business case, particularly if there are overriding safety or quality concerns. Subsequent stages include a review of validation results and critical findings, where the decision to advance the change depends on the outcomes of these tests. The process concludes with

the formulation of a full CR implementation, which precedes a release date for the change after ensuring alignment with all suppliers.

The re-use check serves as an internal tool to specify which component(s) are targeted for change and assess the impact of this change on other components. Additionally, it determines the necessary tests in case of redesign, supplier change, or material alteration for the manufacturing of the component.

The figure also shows the PPAP step which stands for Production Part Approval Process. This process is commonly used in the automotive industry and other related manufacturing industries that require establishing confidence in the supplier manufacturing process. In addition, it ensures that suppliers fulfill customer requirements and specifications according to the relevant standards of the industries.

This is achieved by implementing a sequence of steps and securing agreed evidence packages to demonstrate the reliable manufacturing capability of the suppliers. The process also includes securing prototypes, solid manufacturing processes, quality control plans, incoming quality control, and finally, customer approval before releasing the mass production.

Based on the interviews, in addition to frequently changing priorities, the team members voiced concerns regarding the main bottleneck in executing change requests: defining tests. They agreed that while other activities were straightforward, defining tests was a significant cause of delay.

This delay is derived from 3 primary reasons. Firstly, internally, arranging multiple reuse check meetings with the stakeholders across different teams to define scope, validation procedures, testing specifications, and duration proves challenging. This difficulty is compounded by the lack of experience among some team members, who may struggle to define the scope or assess the impact due to being new to the company or having other commitments for the quarter or year. Consequently, this often leads to delays in the change request process, even though 60-70% of the topics were old and have been executed

previously. As the mechanical expert noted, "After 2 months of digging, I remembered that I made this change 5 years ago."

Figure 5 shows the re-use check percentage from the total CR execution time, it shows in general an average of 20% of the CR execution time.

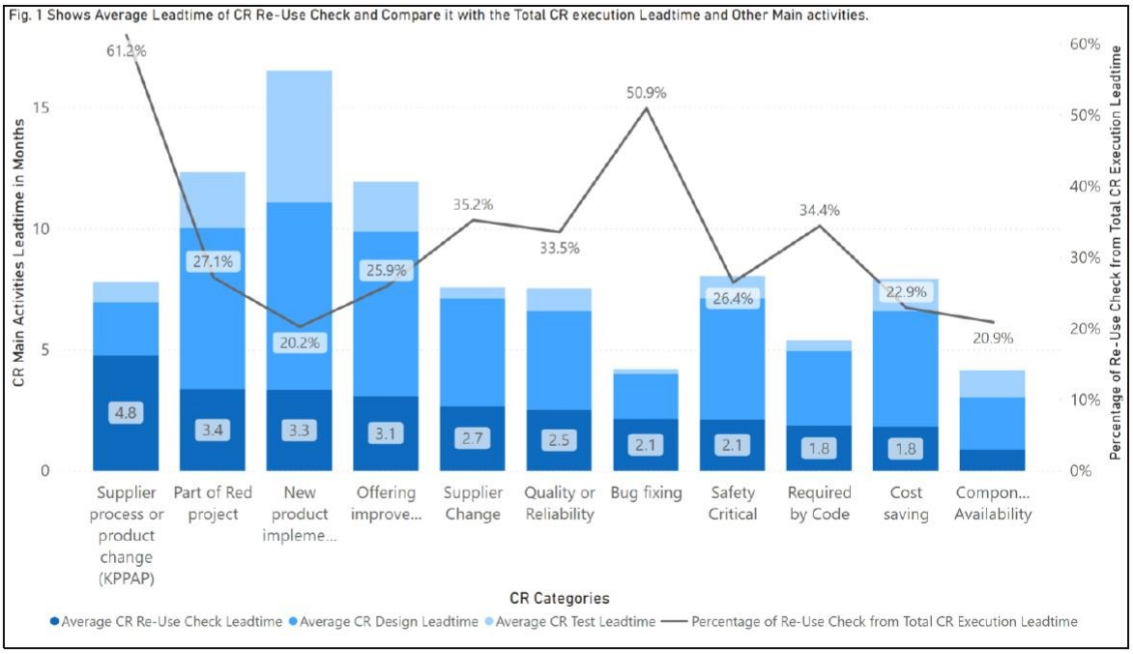

Figure 5. Re-use check lead time per CR category.

As illustrated in the figure, an analysis of CRs from 2009 to 2023 reveals that the re-use check step consumes a significant portion of the total CR execution time, particularly for CRs that involve suppliers. This emphasizes its considerable impact on the efficiency of the CR process when external suppliers were involved.

The second reason arises from the persistence of employing the identical process regardless of the criticality of the scope. In certain instances, the change request pertains to a non-critical component or necessitates only a minor alteration. By adhering to the aforementioned procedure, significant costs and time consumption were incurred. Consequently, the product owner proposed implementing a streamlined process tailored to the criticality of the component undergoing modification.

“changing a press nut changing a motor, there is no difference in the process” claimed the product Owner describing the fixed process despite the differences in the scope.

For less critical changes or minor adjustments, a lighter process or one that varies based on the components criticality was recommended in the interviews. This approach aims to minimize costs and time associated with change requests that do not warrant the extensive procedures of the standard process. By adopting a flexible approach that aligns with the level of criticality, resources can be allocated more efficiently, ensuring that the process remains both cost-effective and time-efficient.

The third reason is linked to external suppliers, whose processes for changing products or components differ from those of the case company. Before raising any concerns, external suppliers typically begin their validation process independently and then seek alignment. This discrepancy was viewed as costly and time-consuming.

“We start validating, they start validating and no one knows what is going on” explained by the mechanical expert.

Furthermore, there were opportunities for improvement in both behavior and process. For instance, implementing standardized procedures for defining tests and establishing better communication channels with external suppliers could help streamline the change request process and reduce delays. Additionally, investing in training and development programs for new team members to enhance their understanding of the company processes and requirements could mitigate the impact of inexperience on the execution of change requests.

3.3 Summary of Strengths and Weaknesses

This section lists the strengths and weaknesses of the currently existing change request execution process according to the current state analysis conclusions and observations.

Based on conducted interviews and considering the currently existing process described in the above section, it was clear that the current process is solid as it has been running for more than 30 years.

Table 1 describes the key strengths and weaknesses based on CSA

Strengths	*Weaknesses*
1. Process Approval Gates for Monitoring The process features approval gates at various milestones, ensuring transparency and managerial oversight, with pre-defined approvals from steering members.	1. One CR Execution Process The CR execution process lacks flexibility regardless of the importance or scope, leading to inefficiencies and unnecessary resource expenditure.
2. Powerful Tools Utilizes robust tools such as PPAP and DFMEA to address all areas of concern and ensure the quality of the validation process.	2. No Filtration for Repeated CRs The process does not adapt when handling repeated change requests, often ignoring previously completed steps, leading to redundancy and inefficiency.
3. Powerful Instructions and Procedures The Product Data Management (PDM) platform offers comprehensive instructions and supports clear process comprehension, beneficial for new hires and ongoing guidance.	3. Supplier validation process alignment Lack of harmonization in the validation process with suppliers, creating potential delays and inconsistencies.
4. Diversified Technical Team A diverse team brings a variety of technical expertise and perspectives, enhancing innovation and problem-solving capabilities across different projects.	4. Supplier testing process alignment Supplier testing processes were not well-aligned with internal standards, which can lead to issues in quality control and longer lead times.

5. High-Tech Testing Facilities Testing facilities enable sophisticated validation and quality assurance, contributing to high standards of product development.	5. Change request (CR) tools knowledge A lack of comprehensive knowledge of CR tools within the team may lead to suboptimal utilization and inefficiencies in the CR process.
6. Suppliers Maturity Mature suppliers with established processes and a track record of reliability add value to the supply chain and ensure consistent quality and delivery.	6. Lack of Time Restrictions The absence of agreed time restrictions leads to project delays and a lack of urgency in resolving issues, contributing to timeline slippage.

Table 1. Strengths and weaknesses.

The strengths of the current process lie in its structured approval gates ensuring transparency and managerial oversight, the utilization of robust tools such as PPAP and DFMEA for successful validation, and detailed PDM procedures providing clarity and support. Additionally, the team diversity brings a broad range of technical expertise, augmented by state-of-the-art testing facilities that uphold high development standards, and mature suppliers with reliable processes. Conversely, the process is limited to a one-size-fits-all CR execution process, lack of adaptability in handling repeated topics, misaligned validation, and testing processes with suppliers, inadequate knowledge of CR tools within the team, and the absence of stringent time restrictions which can lead to delays and inefficiencies.

Three primary weaknesses were selected to focus on as an output of the CSA of the current CR execution process:

1. No gate check for repeated topics.
2. One CR execution process.
3. supplier validation and testing process alignment.

Moving to the next section, this study investigates best practices discussed in relevant literature to address the weaknesses identified in the CSA. This includes analyzing effective practices and concepts to resolve the identified issues,

ultimately resulting in the formulation of a guideline for improving the existing CR execution process.

4 Potential Improvement Ideas from Literature

This section explores potential improvement ideas drawn from literature and CSA, targeting to solve the three primary challenges identified as crucial by leveraging insights from key publications in the fields of operational excellence, lean product lifecycle management, knowledge management, strategic supply chain management, and continuous improvement methodologies, this analysis aims to offer a comprehensive suite of strategies designed to enhance efficiency, reduce costs, and improve overall operational resilience.

The selection and synthesis of literature were guided by the principle of practical applicability, ensuring that the frameworks and best practices discussed were not only theoretically robust but also actionable within the industry context.

4.1 Managing Repetition in Change Requests

Repetition in change requests refers to the occurrence of similar or identical requests for changes to design, materials, or processes within an organization, without the realization that such requests have been made previously.

This redundancy leads to unnecessary consumption of resources and diverts attention away from the novel improvements, ultimately impacting the operational efficiency and innovation potential of the organization. For the case company industry, managing repetition effectively can lead to significant cost savings, improved resource efficiency, and lower resource utilization levels.

The research delved into the selected weaknesses within the organizational framework: the lack of adaptability in the CR execution process, the routine management of repeated CR topics, the misalignment between supplier

validation and testing procedures with established internal standards, and the inadequate understanding of CR tools among the workforce. These insights from Duggan (2012), Viki et al. (2018), and Dalkir (2011) were utilized for analyzing weaknesses collected from the current state analysis, which showed that refining the operational efficiencies is a necessity that innovative methodologies could achieve.

Duggan (2012) advocates the concept of designing systems to effectively minimize waste and avoid redundancy if applicable by implementing a visual workplace where every change request is accessible and trackable in real time. This aids in identifying and resolving repeated change requests. In addition, it ensures full control over the CR process of execution.

Similarly, a continuous feedback loop was outlined by Viki et al. (2018) during the product development to ensure that the product lifecycle is examined effectively, this can be achieved by establishing a lean evaluation framework where organizations such as the R&D of the case company can swiftly determine the impact of the change request from customer value point and view and organizational objective point of view. Accordingly, the framework filters out the non-necessary change requests and ensures resources focus only on the impactful changes.

Dalkir (2005) provides a strategy for knowledge management as a tool to manage and benefit from the previously executed CRs. The Knowledge Repository is an explicit foundational tool in which the detailed history, outcomes, and lessons learned from each CR are recorded to avoid executing redundant change requests.

The Integration of the above-mentioned frameworks aims to address and rectify the operational deficiencies and ensures a more efficient, and agile operational environment.

4.1.1 Implement Visual Workplace Integration

The visual workplace concept was introduced by Duggan (2012) where full visibility of all the execution processes is required using a visual management system. This system proactively aids in sniping potential repeated change request topics before launching the change request execution activities to ensure an efficient process.

The integration of a Visual Workplace is crucial in transforming the efficiency and transparency of production processes. This approach significantly shifts how operations are managed by making the flow of work visibly clear to all employees, thereby facilitating a self-managing environment where problems and inefficiencies are readily apparent and can be addressed swiftly. (Duggan, 2012)

In the context of implementing a Visual Workplace, a comprehensive strategy was outlined, that involves not only the physical rearrangement of workspaces to align with the flow of products but also extends deeply into administrative domains. The establishment of a Visual Workplace is marked by significant changes such as the relocation of machinery, formation of workflow cells, and training of personnel to operate within a new, future-state design. These changes are foundational, setting the stage for a workflow that is visible and comprehensible to everyone involved, from the shop floor to the office. (Duggan, 2012)

In operational settings, Duggan (2012) distinguishes between static and dynamic visuals. Static visuals serve as foundational guides, illustrating the normative flow of operations as designed. These include maps and facility layouts that show the pathway of products through various processes, with clear markers such as 'you are here' signs to orient staff.

"Each person who is working in the flow exactly where he is in it and the processes that connect him all the way to the customer" highlighting the critical role of visibility in operational excellence. (Duggan, 2012, Chapter 19)

In the same chapter, Figure 6 shows an example of the flow map. (Duggan, 2012)

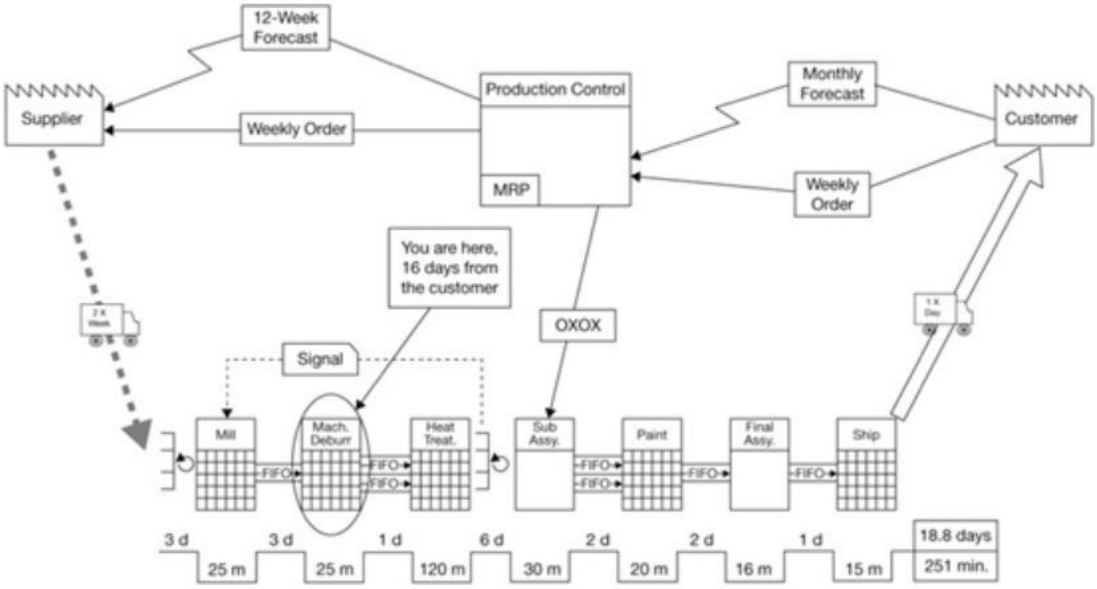

Figure 6. Identifying a process in flow.

By examining this figure, workers can gain a detailed understanding of several key aspects of their work environment:

1. Overall Design for the End-to-End Flow: The diagram displays the flow of actions within the process from the initiation till the product delivery to the customer.
2. Location in the flow: Employees can pinpoint their exact position, role, and responsibility within the process, and how their output influences the next stages of the production or service process.
3. Connection with preceding and succeeding processes: The visual outlines how tasks are linked to preceding and succeeding processes. Understanding these connections ensures that the employee can coordinate effectively with their peers, which leads to a smoother transition between different stages of the workflow.

4. Number of processes to reach the customer: By identifying the number of processes remaining until reaching the customer delivery.
5. Time to customer: The figure provides an estimate of the time required for the product to be delivered.

The integration of visuals into the operational process empowers the employee's knowledge which enhances the process efficiency and increases the employee accountability as well as the level of responsibility as it shows the defined roles and responsibilities of process contributors within complex the process, explains the impact and the influence of the for contributors activities and also indicates a time frame for the total execution process. This approach aligns with the best practices for operational excellence where clear information supports the process improvement and ensures the strategic alignment with the corresponding stakeholders and management within the organization. (Duggan, 2012)

Duggan (2012) further argues that the utility of using these visual principles extends outside the production floor to the office where information flow is as important. The visuals in such situations help harmonize different work processes so that information is efficiently distributed throughout various sections. These tools facilitate ongoing conformance to operations objectives thereby enabling avoidance of convergence by managers and workers with complacency that may result from formal reporting mechanisms or policies which could seem adequate at the time.

4.1.2 Adopt Lean Evaluation Framework

In the dynamic landscape of product development, the Lean Evaluation Framework is required to navigate complexity and foster innovation. The framework emphasizes the necessity of identifying and prioritizing assumptions, while securing a solid evaluation approach to guide decision-making, and continuously aligning with strategic objectives. (Viki et al., 2018)

The identified validation methods and tools such as the prototyping, and the minimum viable product contribute to maintaining a dynamic and continuous feedback channel between the manufacturer, suppliers, and the end customer.

DeWalt, a leading manufacturer of industrial tools innovated a process to ensure the connection with the customer where new tool ideas are shared by customers according to their business and industrial needs. With this customer-centric approach, customers contribute to the ideation process, ensuring commercial viability. Similarly, Lego's collaborative design initiative with its community members, resulting in the commercialization of customer-designed products, epitomizes the integration of customer input into product development, fostering both customer loyalty and innovation. (Viki et al., 2018)

Furthermore, Viki et al. (2018) have explained that the major idea behind using WSJF is to help in prioritization so that more value is obtained in making products where delays will be avoided along with time spent on activities. It also shows how relevant avoiding some pitfalls is when undertaking this process like failing to identify that product development is an adapting system whose state needs to keep on changing with time in response to unforeseen complications.

The cohort analysis is described by the framework as an important method to conclude whether the change improves the outcome or not. In addition, it evaluates the competitive advantage acquired by implementing such change.

4.1.3 Create Knowledge Repository

A knowledge repository is one of the main pillars of the knowledge management frameworks that a company should ensure exists as it guarantees sufficient knowledge required to streamline the execution process, Dalkir (2005) explains that knowledge repositories are designed to store relevant historical data that guides process contributors during the planning and execution phases. Moreover, it provides access to information required for decision-making activities within the organization.

Another key topic highlighted from the literature review is the difference between tacit and explicit knowledge, where tacit knowledge is defined as non-codified, on the other hand, explicit knowledge is more readable, storable, and simpler to utilize. According to Dalkir (2005), the process of converting tacit knowledge into explicit forms ensures wider use of the knowledge within the organization. Specifically, this shift implies structured documentation as well as inclusion in the knowledge repositories so that propagation within the organization could be facilitated.

Dalker (2005) shared some examples showing how to implement the knowledge repository effectively within organizations by embedding the concept in the standard processes and procedures of organizations. Accordingly, it becomes part of the culture and the normal daily operations of the organization. Practices that utilize advanced technological tools and systems are highlighted to manage knowledge repositories efficiently.

Another concept highlighted is that the knowledge repositories are dynamic and require continuous involvement and updates to ensure the evolution of new insights and beneficial information. According to Dalkir, the utilization of content management software tools is to preserve the repositories' relevance and usefulness. This support supports running the knowledge lifetime from creation up to storing it before retrieval and finally the usage, therefore securing the continuous company adaptation and learning. (Dalkir, 2005)

This section showed some improvement ideas, practices, and strategies ensuring a flexible structure that handles fundamental causes of routine alteration claims. Immediate observation of probable duplications is facilitated thus causing instant interference in companies whose visual workplaces are integrated. The Lean Evaluation Framework ensures that only those requests that offer genuine value and alignment with strategic objectives proceed, instilling a disciplined approach to innovation. Finally, the Knowledge Repository solidifies the organization's learning culture, leveraging historical data to inform and optimize future decisions. Collectively, these solutions foster an

environment where efficiency, informed decision-making, and continuous improvement are achieved, steering the case company industry toward a more sustainable and innovative future. (George et al., 2014)

4.2 Aligning Suppliers in Testing and Validation

The challenge of aligning suppliers in testing and validation processes is a critical one in the case company's industry, where safety, reliability, and efficiency are essential. The insights gleaned from Hübner (2007), and Cohen and Roussel (2013) offer valuable perspectives on establishing effective collaborations between companies and their suppliers.

Hübner (2007) explores the supply chain management for industries by explaining the importance of the creation of a standard process for production and delivery operations. Also suggested that the alignment between companies and suppliers significantly streamlines the testing and validation processes and ensures that safety and quality standards are efficiently fulfilled with no significant disturbance to the processes.

In literature, Hübner (2007) explains how a Standardized Testing Framework, Supplier Integration in Design, and a Mutual Validation Protocol can contribute to streamlining the execution process, reduce waste, and avoid delays due to process adjustment. Also from the product perspective, it ensures that the product meets the required level of quality, safety, and functionality.

4.2.1 Develop a Standard Testing Framework

A standard testing framework is designed to ensure the efficiency of the testing and validation processes and also to guarantee that the production processes are efficient enough to achieve the intended level of quality of the products. In addition, it is obliged to be adaptable to the technological changes impacting the industry. (Hübner, 2007)

According to Hübner (2007), the Implementation of a standard framework for testing secures a systematic approach for process evaluation and optimization knowing that it is appliable to complex industries that require a high level of assessment for the outcome product and also require an adequate level of data for decision-making activities.

The framework utilizes several simulation tools in modeling production procedures and testing different configurations under a variety of situations. Consequently, this is used in determining the most effective arrangement of the production facilities as well as the logistical operations. An important part of the framework is the inclusion of robustness tests. These tests evaluate how well a production network can cope with disturbances or changes in market conditions. To measure how resilient their network design is, companies can examine it by running different adverse scenarios like missing raw materials or altered demand.

Additionally, the framework explains the modular approach where companies can implement some adjustments to parts of the process without disrupting the currently running operations. Accordingly, this adds more flexibility and scalability.

Eventually, the standard framework for testing as described by Hübner (2007) provides a robust strategy for managing complex production activities for industries known for its complexity. It combines theoretical understanding with practical flexibility to produce sort of a tool to optimize the production process and secure a more adaptable and dynamic nature for the production activities.

4.2.2 Involve Supplier in Design Process

On the other hand, Cohen and Roussel (2013) delve more into strategic aspects concerning supply chain management by highlighting the importance of collaboration and integration of the supply chain in the early stages of the design and product development process. In addition to that, the supplier

involvement in the early stages of design and development impacts directly the swiftness of communication and collaboration which can be translated to less engineering cost and less team utilization. This also leads to an outcome of complying with all testing and validation standards required by organizations and customers. The introduced strategy influences companies aiming to enhance the performance of their supply chain efficiency and prosper the innovation capabilities through strategic partnerships.

Cohen and Roussel (2013) introduced a study on a supplier relationship from the automotive industry where the co-development of products has resulted in technological improvements and significant cost savings. The relationship is based on strong frameworks that facilitate both parties to gain from each other through joint technology and process investments plus distinct goals that are aligned with their strategies.

Furthermore, Cohen and Roussel (2013) stress on the importance of embedding periodic evaluation of the collaborative model built between the companies and their supply chain to control and adjust based on market and business needs to ensure the competitive edge of the organization.

Eventually, the process of integrating the suppliers in the design requires a deliberate adjustment and extensive cooperation between organizations and supply chains. Apart from boosting novelty and performance, it ensures a base for maintaining a market edge. Effective strategic supplier integration capitalizes on the merits of both partners to achieve common and individual business targets. (Cohen and Roussel, 2013)

4.2.3 Establish a Mutual Validation Protocol

A mutual validation protocol as defined by Stapelberg (2009) involves a systematic framework to ensure that all engineering design requirements and specifications are met. In addition, it assures that essential reliability and safety standard targets are fulfilled by utilizing dedicated testing and validation

processes by including methods for verification and validation of engineering models. The verification concept involves testing the product with respect to the predefined functional criteria to confirm the proper operation, while the validation is comparing the simulated performance against the actual performance data of the product. Accordingly, and by having both concepts present, the behavior of the product and accurately measured and assessed.

In industrial applications, especially for large and complex processes that involve multiple sub-systems, the protocol helps to mitigate the risks associated with system complexity by ensuring that components and sub-components are tested individually and assembled with other components. This comprehensive testing ensures proper validation for the whole system. Stapelberg highlighted the significance of the proper verification and validation processes by claiming “Model validation is the process of developing an acceptable level of confidence that an inference regarding the results of a simulated process is a valid inference for the outputs of the real system" (Stapelberg 2009: 501).

This statement explains the importance of the dedicated validation process to achieve reliable, maintainable, and safe engineering designs and end products.

4.3 Establishing Continuous Improvement Post-Change Request Execution

Continuous improvement post-change request execution step is essential to evaluate and ensure that changes executed are complying with the intended predefined targets within the expected timeline for execution.

George et al. (2005) emphasize the significance of utilizing the feedback information from the execution processes for adjusting and tuning the process and making decisions seeking continuous improvement. Also, the importance of applying Lean Six Sigma principles to streamline the existing processes by reducing waste, and enhancing the quality of the product and the process. The methodology encourages continuous evaluation and adjustment of

manufacturing processes to ensure that the changes are correctly implemented and the processes are streamlined and refined.

Stapelberg (2009) describes the main principles that should be followed when designing safe, maintainable, and secure systems. Also explained the importance of including these ideas received from the feedback of the current processes while enhancing the existing manufacturing process so that any modification enhances the overall performance of the system in the long run.

4.3.1 Implement Lean Six Sigma Methodologies

The concept of establishing a continuous improvement framework can be built on a solid foundation by merging the principles of lean process for reducing waste and the main principles of Six Sigma for reducing variations to enhance the quality and speed of the processes. In other words, the lean process principle aims to streamline operations by spotting and eliminating the no-added value activities to simplify the workflow and reduce wasted time on non-required activities, while Six Sigma principles ensure the utilization of previous data collected to reduce the defects in the process. The implementation of the framework starts with defining defects in the existing process, then defining value added for each process step to identify and eliminate inefficiencies, and next the definition of the root cause of variability process activities. (George et al., 2005)

Practical techniques were also introduced for mistake-proofing and process reduction to eliminate process flow issues and reduce execution time. Also, control charts and process capability analysis were explained. These practices confirm the stability of the production process by requesting a specific amount of production samples, the suppliers are obliged to perform certain measurements for critical parameters, and based on the consistency of the result, the production process is confirmed as reliable and stable. (George et al., 2005: 223, 233.)

4.3.2 Develop a Continuous Feedback Loop

The development of a continuous feedback loop is crucial for monitoring the efficiency of the existing execution processes and ensuring continuous improvement of the processes. The feedback cycle starts with the collection of data after a partial or full process completion, then data analysis takes place to filter the potential improvement opportunities to the existing process. Also, quick fixes were introduced for minor changes in the process whenever safe to implement for the elimination of process inefficiencies. This approach is effective as the adjustment is implemented swiftly and the disruption to the process is minimal which emphasizes the benefit of reducing the time between defining the potential improvement and preparing a test to assess the impact of the improvement on the current process. (George et al., 2005)

Moreover, the feedback loop concept is extended to production pilots where the changes are tested to simulate the performance and functionality before releasing into the full implementation. Accordingly, the change impact is tested to ensure effectiveness and target fulfillment and reduce the risk of failure. (George et al., 2005: 273.)

Eventually, the primary objective of this approach is to support immediate operational improvements. It also seeks to instill an organizational ethos characterized by continuous improvement and learning.

4.3.3 Integrate Reliability and Safety Considerations

Stapelberg (2009) emphasized that reliability and safety considerations are counted as critical elements of the engineering design processes due to the significant influence of ensuring a functional, durable, and safe operation. Moreover, methodologies such as RCM and HAZOP are counted as essential tools to identify and assess potential risks associated with system failures and accordingly ensure the safety and functionality of the outcome.

Additionally, creating a continuous feedback loop allows companies to remain flexible and respond rapidly to constructive feedback. This ensures the alignment of activities aimed at enhancing the process operations to achieve customer requirements. Furthermore, including reliability and safety considerations confirms the dedication towards upholding the optimum system performance levels as well as ensuring the safety measures according to standards. (Stapelberg, 2009)

4.4 Conceptual Framework

This section presents the CF, which addressed the three main challenges outlined in the Current State Analysis for the case company. Illustrated in Figure 7, the CF was composed of essential elements and solutions based on a review of literature and recognized best practices.

Each element of the CF was designed to improve operational efficiency and guarantee product quality and safety.

Figure 7. Conceptual framework.

The conceptual framework highlighted in Figure 7 was designed to tackle the three main improvement areas identified in the CSA and the literature review.

The first key component is aimed at the management of the repetition of change requests which involves ideas to reduce this repetition such as improving the visibility of the process flow and decision-making capabilities through the implementation of a visual workplace, and a robust knowledge repository that includes historical data to minimize redundancy, and accordingly decrease resources utilization level.

The second key component of the framework was the enhancement of supplier testing and validation alignment by involving the supply chain from the early stages of designing till the definition of testing and validation activities and targets. This ensures the mutual understanding of safety and quality requirements and standards.

The third key component of the framework describes the importance of establishing a continuous feedback loop initialed after partial or full

implementation of the change request. This component focuses on embedding continuous improvement mechanisms and integrating safety and reliability considerations. Also, the framework utilizes the principles of the Lean process to reduce waste and the Six Sigma principle to minimize process variation. This aims to increase the process efficiency and reduce the cost and time of the execution.

In the next section, the initial proposal will be built based on the conceptual framework, and the current state analysis findings.

5 Building Proposal for Developing a CR Execution Guideline

This section outlines the initial proposal for developing a CR execution guideline for the R&D department of the case company. The proposal was designed based on the findings from the current state analysis and the conceptual framework and was ensured to fit into the existing CR execution process. The initial proposal aimed to simplify and accelerate the current CR execution process.

5.1 Overview of Initial CR Execution Guideline Building Stage

This section describes the initial stage of developing the initial guideline for the CR execution process. The stage started with two planned individual interviews, 30 minutes each with a supplier quality manager and the case company quality engineer. The purpose of the interviews was to collect improvement ideas based on the current state analysis and the conceptual framework.

A full-day workshop was arranged to brainstorm improvement ideas and co-create the initial proposal. The benefit of the workshop is that guideline practicalities were discussed to ensure compliance with various R&D functions and process subtasks.

The below list shows the core team co-created the initial proposal:

- Product Owner
- Projects Lead
- Electrical Expert
- Mechanical Expert
- Electronics Expert.
- Quality Engineer.
- Tribe Leader.
- Supplier Quality Manager.

The guideline was co-created by the team by combining practical knowledge presented in the core team selected for this task and the theoretical understanding acquired from the best practices dug out of the literature

In addition, a steering meeting was held with the case company management, where the initial proposal was presented. The outcome ensured that the guideline objectives matched with the case company strategic direction and managerial expectations.

In documenting the proposal-building stage for the CR execution guideline, a detailed MoM was prepared for the full-day workshop outlining the discussions, decisions, and action points given to individual team members based on their knowledge.

The initial proposal implementation timeline was established to define deadlines and milestones and ensure the swift execution of agreed tasks.

5.2 Finding of Data Collection 2

Addressing the business challenges outlined at the outset of this study, the proposed outcome was to introduce CR execution guideline. This solution was specifically tailored to tackle the weak spots highlighted in the Current State Analysis and to be continually enhanced by the adaptive strategies derived from the Conceptual Framework.

The CSA revealed several critical weaknesses, such as the lack of gate checks for repeated CRs, one-size-fits-all CR execution processes, and misalignment in supplier validation and testing procedures. These weaknesses were then taken as focal points within the CF, which suggested key components, for example, streamlined gate checks, flexible process paths for different types of CRs, and integrated validation protocols with suppliers.

This involves multiple methods, data sources, perspectives, or theories to investigate a single topic or problem. The idea behind this is to cross-validate findings, enhancing the credibility and reliability of the results. The study delved into the literature to uncover best practices that could effectively respond to these weaknesses. This triangulated approach ensured that the practices chosen were not only rooted in proven theory but also pragmatically viable for the case company operations.

5.2.1 Managing CR Repetition

This section of the thesis tackles the first weakness identified in the current state analysis which was how to manage CR repetition and explains solution strategies derived from the conceptual framework findings and practices. It has presented a set of strategies formulated by the key stakeholders to mitigate consuming more time with repeated change requests.

It was very clear from the interviews that there were many problems caused due to misunderstanding of the scope of the CRs, and more work to avoid if the correct understanding was received.

“Scope of the CR has to be more clear and sufficient to build a case” Explained by Mechanical expert.

It was something that all the stakeholders agreed on, also product owner suggested having a fixed defined scope of work for the CR as the discrepancies between the commercial offer scope definition and the technical offer scope definition cost the teams more time to approve the business cases.

“Some sort of a checklist could be useful here.” Suggested by the Product Owner and project lead.

It was agreed that a checklist is the key to securing a high level of detail and a high level of accuracy for the scope definition step.

Table 2 describes stakeholders suggestions addressing the first weakness identified by the CSA, which is the lack of gate checking for CR repetition.

	Key Focus areas from CSA (Data 1) and the element of CF	*Suggestions from Stakeholders (Data Plan 2)*	*Description of the Suggestions*
1	Gate Checking for Repeated CRs	a) Define the Parameters of the Scope Definition of the CR Execution Process b) Define CR Type c) Provide Reference CRs	The stakeholders suggested implementing a more specific checklist to define the CR scope, this assures the level of information and avoids back-and-forth emails and un-needed meetings
		a) Request the Supplier to Implement a CR database b) CR Steering Meeting every month to review blockers and discuss general improvement topics	The stakeholders agreed to request the suppliers to implement their own CR database to secure the trackability. This guarantees historical data and CR information. The stakeholders Suggested having a monthly meeting with All suppliers to review the Current CR status. This secures continuous follow-up and supplier alignment.

Table 2. Key stakeholder's suggestions for proposal building (Data 2) with respect to the repeated CRs weakness from the CSA and the key components from CF.

In addressing the CSA-identified issue of gate checking for repeated CRs, stakeholders suggest several key actions. They propose a detailed checklist for defining the CR scope, ensuring that all necessary information is clear from the

outset and thus mitigating the need for excessive communication. This checklist includes steps such as defining the change, identifying affected products and components, referencing previous CRs, and proposing necessary validation tests and targets.

Furthermore, the stakeholders recommended the establishment of the CR-type concept where three types were introduced, supplier changes, material changes, or design changes. This will help to categorize and handle each change request properly. To support this, the team suggested the implementation of a CR database by suppliers for better traceability by ensuring access to the historical data and previously executed CR details. Additionally, Monthly CR steering meetings were suggested to be conducted with all suppliers separately to maintain a consistent review of the CR statuses.

Additionally, the core team recommended the implementation of a validation step to assess the level of information presented in the scope definition checklist. The validation step was agreed to take place within a week of receiving the input checklist which was designed to ensure that the information provided is accurate and comprehensive. Moreover, It was agreed to conduct a thirty-minute meeting if needed with the CR initiator to facilitate the understanding of the CR scope and discuss the objective and the execution timeline. This proactive step aims to prevent miscommunications and align all parties on expectations and deliverables from the beginning.

5.2.2 One CR Execution Process

This section addresses the second weakness identified in the CSA which was having One CR execution process for all. It explores strategies developed from findings within the CF and established practices. The section details recommendations co-created by key stakeholders, aimed at introducing flexibility and efficiency to the process. These recommendations center on customizing the CR execution steps based on specific CR types and historical data, potentially allowing for bypassing certain steps for repeated or similar CRs. This tailored approach was designed to expedite the CR process and adapt it more closely to the unique circumstances of each request.

Table 3 outlines stakeholder solutions for improving the one CR execution process key focus area, identified as the second weakness point from the CSA. It includes suggestions from stakeholders on how to solve this weakness.

	Key Focus areas from CSA (Data 1) and the element of CF	*Suggestions from Stakeholders (Data Plan 2)*	*Description of the Suggestions*
2	One CR Execution Process	a) Skip Steps of the CR Execution Process in Case of Repeated Topics b) Use Reference CRs to define Test Scopes and Test Targets	The stakeholders suggested adding a skip process option within the CR process execution if the CR topic is repeated or if there were previously defined validation and testing parameters applicable for the newly presented CR topic using clear

			criteria to ensure the integrity of the CR process.
		Create CR Classification	The stakeholders suggested implementing a new CR categorization (Criticality & Class).
		a) Create a Light Version of the CR Process b) Create a Light Version of Quality documents based on CR Classification	The stakeholders suggested implementing a Light CR Execution Process for Non-critical CRs and low classes by limiting the Re-use check activities, quality documents required and more focus on validation measures utilized by the suppliers

Table 3. Key stakeholder's suggestions for proposal building (Data 2) with respect to the weakness of the One CR execution process from the CSA and the key components from CF.

The first column of the table points out the uniform approach to handling CRs as a key area needing reform. Traditionally, this one-size-fits-all method has led to inefficiencies, especially when dealing with CR topics that recur or closely resemble past issues.

Responding to this, stakeholders put forth several suggestions, as noted in the second column. They propose an adaptive process that includes skipping the re-use check step when dealing with repeated CR topics, which would prevent redundant work and save time. This would be guided by a clear set of criteria to

determine when it is appropriate to omit steps, ensuring that the integrity of the CR process is not compromised.

This matches the first suggestion involves using historical data to inform current CRs. By referencing similar cases from the past, stakeholders believe that the company can more quickly define the tests and test targets necessary for new CRs, leveraging established knowledge and avoiding the need to start from scratch each time.

“Can we skip the re-use check?” Suggested the electronics expert, in an indication for skipping the Re-Use check step if the same CR topic or a new case where a previously applicable validation was already done.

Moreover, stakeholders call for the creation of a CR classification system. This new system would categorize CRs based on their criticality and class, allowing for a more nuanced approach to CR management. This categorization would help prioritize based on the criticality of the topic, ensuring that resources were allocated effectively and that urgent or high-impact CRs were addressed with the attention they require.

Lastly, the table presents the suggestion for developing a light CR Execution Process for non-critical CRs.

Each of these suggestions comes with a detailed explanation in the third column, underscoring how they collectively serve to refine the CR execution process. Stakeholders emphasized the need for a more dynamic, responsive approach that can differentiate between CRs and apply the most efficient procedure accordingly. Implementing these ideas targets overcoming the single CR execution process and enhances the case company ability to manage CRs with greater agility and effectiveness.

This streamlined process focuses on the essential validation measures by minimizing the extensive re-use check activities if possible that may not be

necessary for less critical CRs. Such a process would enable the company to handle lower-risk CRs as shown in Figure 8 efficiently.

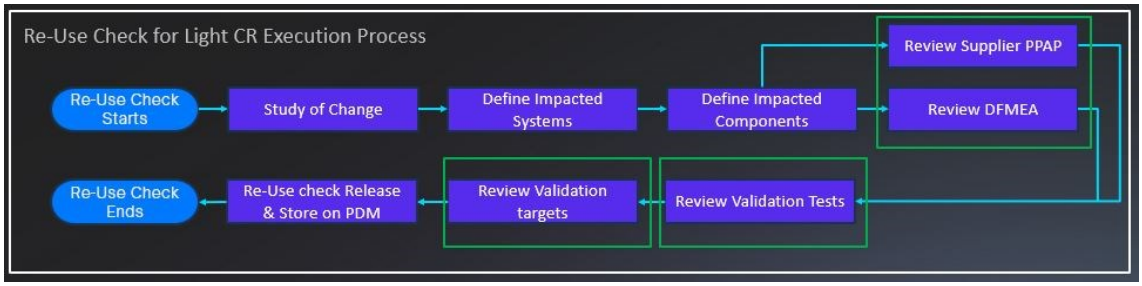

Figure 8. Re-use check for light CR process.

5.2.3 Supplier Validation and Testing Process Alignment

This section discusses the third weakness identified during the current state analysis stage which was the supplier validation and testing process alignment. based on strategies described in the conceptual framework and industry best practices, it lays out a series of suggestions developed with key stakeholders. These suggestions were aimed at streamlining the alignment between the company CR process and the suppliers validation and testing procedures. The objective was to enhance coordination, improve efficiency, and maintain the quality and integrity of the CRs as they relate to supplier interactions.

Table 4 presents stakeholder's suggestions for enhancing the supplier validation and testing process alignment, which was identified as the third area of concern by the CSA. The table contains considered the approach suggested for resolving this particular weakness.

	Key Focus areas from CSA (Data 1) and the	*Suggestions from Stakeholders (Data Plan 2)*	*Description of the Suggestions*

	element of CF		
3	Supplier Validation and Testing Process Alignment	a) Involve Supplier in Testing Scope and Test Targets Definition b) Create a Self Certification Repository (SCR) as a Database for Previously Testing Scope and Test Targets Definition c) Allow a Continuous improvement to the Previously Approved Testing Scope and Test Targets Definition within the (SCR)	The stakeholders suggested to start building a Self Certification Repository (SCR) that includes: 1. All product components. (eventually) 2. Approved Tests for All components. (eventually) 3. Agreed Test Targets and timelines for execution. (eventually) 4. Process for updating the document. Having such a document would accelerate the testing and validation definition and also keep the suppliers aligned and secure suppliers access to company testing procedures. Also, grant the chance to skip the testing definition if a reference CR exists. SCR comprises KPIs based on historical data and previously executed CRs

Table 4. Key stakeholder's suggestions for proposal building (Data 2) with respect to the weakness of the supplier validation and testing process alignment from the CSA and the key components from CF.

Table 4 delves into enhancing the supplier validation and testing process Alignment, addressing the third weakness highlighted in the CSA. This table showcases stakeholders suggestions for creating a dynamic and collaborative environment for CR validation and testing procedures. The introduction of the SCR as a central element of the proposed approach. This live document serves as a comprehensive database, compiling all product components and their associated testing procedures and targets. It is anticipated to be updated regularly following each CR, particularly when new validation requirements emerge or adjustments are needed, ensuring that the SCR remains current and relevant.

The SCR includes a broad spectrum of entries, from product components to approved tests for each, along with agreed-upon targets and timelines for execution. Therefore it fosters a proactive approach, where suppliers are involved in the testing and validation definitions from the start, thereby expediting the process. More importantly, by maintaining an up-to-date SCR, suppliers gain direct access to the company testing procedures, ensuring consistent adherence to quality and safety standards.

Furthermore, the SCR provides a guideline for continuous improvement within the CR process. As a living document, it can adapt and evolve, encapsulating lessons learned and new insights from each CR cycle. By allowing for this evolution, the SCR ensures that validation and testing methods stay at the forefront of industry practices and regulatory requirements.

“This document will not be ready now” pointed out by the Product Owner to explain that this is a non-stop continuous activity to keep updating the live document.

The SCR incorporates execution KPIs that draw on historical data and insights from previously implemented CRs.Table 5 shows the proposed Targets for CR execution based on historical data and team experience for different types of CRs and classes.

CR Type	Expected Min	Expected Average (target)	Expected Max
Supplier Change	90 Days	60 Days	30 Days
Material Change	120 Days	90 Days	60 Days
Design Change	180 Days	120 Days	60 Days

Table 5. CR execution duration KPI

Notably, this approach also allows bypassing certain testing definition steps if similar CRs have been executed previously, evidenced by a reference CR in the repository. This ensures efficiency and avoids unnecessary repetition, ultimately contributing to a more streamlined CR process that upholds the highest standards of product quality and safety.

5.2.4 Summary of the Initial Proposal for Developing a CR Execution Guideline

This section summarizes the initial proposal co-created by the team, drawing upon suggestions refined through a literature review and the insights of the CF. It outlines a collaborative strategy to enhance the CR process, addressing specific inefficiencies and aligning with best practices for continuous improvement.

To manage CR repetition, a comprehensive checklist was proposed to define the change, detail the impacted components, and outline necessary validation tests and targets according to the CR initiator. Also defining CR type whether it is a design change, material change, or supplier change, defines the areas of

testing and helps to know how to utilize the previous validation and testing understanding. This tool aims to ensure all required information is captured at the outset, reducing the cycle of revisions and communication. Additionally, the suggestion of a monthly CR steering meeting aims to bring stakeholders together to maintain an ongoing dialogue regarding current CRs, fostering continuous follow-up and alignment, particularly with suppliers.

In tackling the alignment of supplier validation and testing processes, the creation of a SCR was presented. The SCR was anticipated as a dynamic, living document that catalogs all product components and their corresponding testing procedures and targets. As a continually updated resource, the SCR is designed to streamline the validation process, providing suppliers with immediate access to up-to-date testing procedures and enabling a more rapid response to CRs. Importantly, it also allows for the possibility of bypassing redundant testing activities when applicable, based on previously executed reference CRs.

Figure 9 is a snapshot from the initially created SCR document showing the structure of the validation and test definition sheet.

Car Door Lock Contact assembly	classification	A	A	A	A	A	A	A	A
	no. of samples	1	1	1	1	1	1	8	8
	Standard& Pass criteria	Car Door Operator assembly	Car Door Lc	Landing Mechanism assembly	Landing door lock assembly	Lock latch/ Lock notch	Lock component	Hanger Roller	Counter Roller
Close force measurement (electrical test)		o	o	o	o	o	o	o	o
Gear stress test (Vandal) – (12 motors)		o	o	o	o	o	o	o	o
Salt Spray test (ITA)		o	o	o	o	o	o	o	o
Compatibility Belt - Motor and Diverting pulley		o	o	o	o	o	o	o	o
Noise test		x	x	x	x	x	x	x	x
Installation Test		x	x	x	x	x	x	o	o
Cold non-operational test	IEC 60068-2-1								
Dry heat non-operational test	IEC 60068-2-2								
Change of temperature operational test	IEC 60068-2-14								
Cold operational test	IEC 60068-2-1								

Figure 9. SCR validation and test definition sheet.

As described in Figure 9, the first column shows the different tests, while in the top rows components and component classifications are presented.

To define the tests and test targets for a specific component, the CR owner checks the “x” corresponding to the tests, number of samples, validation targets, and passing criteria according to the standards.

Figure 10 shows the initial proposal structure for the CR execution guideline.

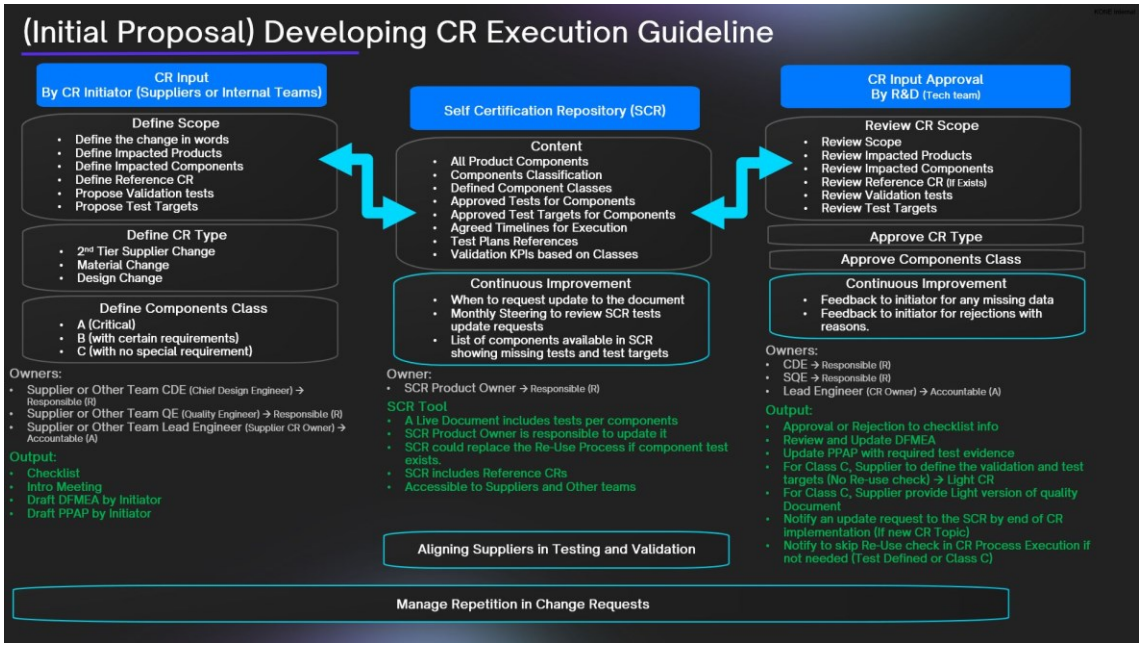

Figure 10. The initial proposal for the CR execution guideline structure.

As described in the figure, The initial proposal structure for the CR guideline illustrates a systematic transfer of information between key components of the process. This structure ensures that the scope definition checklist step effectively communicates necessary data to the SCR, facilitating the precise definition of tests, validation actions, and test targets. Additionally, there is a critical exchange of data from and to the scope definition validation step, which confirms the applicability of the tests outlined in the SCR and defines if a new test is to be added to the SCR or not. This process was designed to not only streamline the flow of information but also to clarify the roles and responsibilities of the owners at each stage, and the tools utilized to enhance efficiency and accuracy in CR execution.

The SCR stands as the cornerstone of the proposed initial strategy, providing CR owners with a refined framework to determine and confirm the CR scope. By leveraging the expertise of subject matter experts, CR criticality, and classification, as well as component categories, the SCR enables an informed approach to setting tests and objectives. Where applicable, CR owners can adopt a streamlined version of the CR execution process, efficiently validating inputs and employing the recommended tools, such as focused 30-minute meetings and defined KPIs, to carry out CRs in line with the guideline set forth by the SCR.

Moving forward, the piloting and evaluation phase of the formulated CR execution guideline was introduced, describing in more detail how the guideline was put into practice within the R&D department and how it was evaluated to address the identified weaknesses. The implementation process, stakeholder feedback, and any necessary adjustments to the guideline based on real-world applications were discussed. This demonstrates the practical impact of the guideline and their contribution to enhancing the CR execution process in a live environment.

6 Validation of the Proposal for Developing a CR Execution Guideline

This section discusses the validation phase for the CR execution process guideline as it focuses on how the proposal was validated employing piloting and feedback gates. It also focuses on the practical application of the guideline, and the feedback received from stakeholders throughout the piloting process.

6.1 Overview of the Validation for the CR Execution Guideline

This section provides an overview of the validation process for the CR execution guideline.

A piloting approach was suggested for the guideline validation where three CRs were selected for testing the guideline:

1. New motor supplier
2. New material for a motor belt.
3. Improved design for the synchronization system.

For the first two CRs, tests were already defined and included in the SCR. This allowed the supplier to immediately define and execute the necessary tests following scope validation approval from the case company. The new process included a scope checklist presented in the PPAP that was initiated by the supplier, which enhanced the clarity and understanding of the CR scope. A meeting was scheduled for all three topics, and approval on the scope definition was obtained within three days of receiving the notification, highlighting the clarity and efficiency brought by this part of the new guideline.

Two meetings were arranged with the execution team and the supplier to collect feedback

The benefits observed from the first two pilot CRs included:

- Alignment between the supplier and the case company on testing and validation criteria right from the start of the CR process.
- Swift commencement of testing activities by the supplier post-scope validation approval.
- An internal reuse check confirmed that no additional tests were necessary, which took only 15 minutes, significantly reducing the time typically consumed by this process, which the team decided better to keep as a confirmation checkpoint.

Analysis of the CR execution time revealed that the reuse check, which normally accounted for over 20% of the total time for CRs involving suppliers, now only consumed 2.1% of the total 16-month execution timeline for the motor

and belt CRs. This huge reduction in time illustrates the efficiency of the guideline in streamlining the CR execution process.

For the third CR involving a design change classified as Class C, the team attempted to use testing and validation measures proposed by the supplier. Also, requested a light version of the required quality document as aligned with the quality engineer responsible for the CR. However, the preliminary results did not meet the case company testing standards as they failed to stress the new design adequately. Consequently, it was decided to retain the standard Re-use check procedure for this type of CR and also keep using the standard quality documents and requirements to avoid any quality slippage with any process change.

According to the SCR change management procedure, the validation and testing definitions and measures proposed by the supplier were not included in the SCR, as they had not been approved by the case company. This oversight highlights the importance of ensuring that all supplier-proposed changes and testing protocols undergo a review and approval process before they are integrated into the SCR which is the responsibility of the SCR product owner, to maintain the integrity and compliance of the CR process.

The pilot testing of the new CR guideline demonstrated significant improvements in process efficiency and alignment between stakeholders, by using the scope definition checklist and governance, scope definition validation step, and also utilizing and updating the SCR as a backup live reference for all components tested previously.

The pilot tests not only demonstrated the effectiveness of the new CR execution guideline but also highlighted important areas for refinement, particularly regarding the implementation of the light version of the CR process and associated quality documents. During the evaluation of a class C component CR which is the least critical in terms of safety and quality measures, which involved adopting testing and validation measures proposed by the supplier, the

outcomes were suboptimal. The results did not meet the case company testing standards, suggesting that the new design was not subjected to adequate stress levels.

In conclusion, it was decided to retain the standard CR and quality documentation processes for class C components.

However, the utilization of the SCR plays a critical role in minimizing the duration required to define tests and validation measures, ensuring that even when standard processes are used, they are executed more efficiently. This balanced approach allows for both the maintenance of high-quality standards and the realization of efficiency improvements where feasible.

6.2 Adjustment to the Initial Proposal

This section consolidates the adjustments to the CR execution guideline based on the validation and feedback received during the pilot phase detailed in earlier sections. It outlines the final proposals for the CR execution guideline.

Table 6 presents stakeholder's suggestions for enhancing the initial proposal of the CR execution guideline, drawing on insights gained from the implementation of pilot CRs. These suggestions reflect practical feedback aimed at refining the guideline to better meet operational needs and streamline the CR process.

	Key Focus areas from CSA (Data 1) and the element of CF	*Suggestions from Stakeholders (Data Plan 3)*	*Description of the Suggestions*
1	Gate checking for Repeated CRs	d) Define the Parameters of the Scope Definition of the CR Execution Process e) Define CR Type f) Provide Reference CRs	The stakeholders suggested implementing a more specific checklist to define the CR scope, this ensures the level of information and avoids back-and-forth emails and unneeded meetings. Positive feedback
		c) Request Supplier to Implement a CRs database d) CR Steering Meeting every month to review	The stakeholders agreed to request the suppliers to implement their own CR database to secure the trackability. This guarantees historical data and CR information.

		blockers and general improvement topics	The stakeholders suggested having a monthly meeting with All suppliers to review the current CR status. This secures continuous follow-up and supplier alignment. Positive feedback
2	One CR Execution Process	a) Skip Steps of the CR Execution Process in Case of Repeated Topics b) Use similar cases to define Tests and test Targets	The Stakeholders suggested keeping the execution process steps while benefiting from SCR If possible New suggestion for the final proposal
		Create CR Classification	The stakeholders suggested implementing a new CR categorization (criticality & class). Positive feedback
		a) Create a Light Version of the CR Process b) Create a Light Version of Quality Documents Based on CR Classification	The stakeholders suggested keeping the same CR execution process unchanged and keeping the Re-Use check step for better visibility. New suggestion for the final proposal

			The stakeholders suggested keeping quality documentation the same. New suggestion for the final proposal
3	Supplier Validation and Testing Process Alignment	a) Involve Supplier in Validation and Testing Process Definition b) Create a Self SCR as a Database for Previously Defined Tests and Validation Methods c) Allow a Continuous Improvement to the Previously Approved Validations and Tests within the SCR	The stakeholders suggested to start building a Self SCR that includes: 1. All product components. (eventually) 2. Approved tests for all components. (eventually) 3. Agreed test targets and timelines for execution. (eventually) 4. Process for updating the document. Having such a document would accelerate the testing and validation definition and also keep the suppliers aligned and secure suppliers access to company testing procedures. Also, grant the chance to skip the testing definition if a reference CR exists. SCR comprises execution KPIs based on historical data and previously executed CRs Positive feedback

Table 6. Stakeholder's feedback and new suggestions for the final improvement proposal (Data 3)

Table 6 summarizes stakeholder final suggestions for refining the CR execution guideline based on pilot feedback. Key areas include enhancing gate checking for repeated CRs by introducing a detailed scope definition checklist and a supplier-managed CR database to streamline communication and improve trackability. Stakeholders recommend maintaining current procedures while optimizing the use of the SCR to skip redundant steps where applicable. In supplier validation and testing, the creation of an SCR was granted to facilitate quick access to test definitions and improve alignment with supplier processes.

6.3 Final Proposal for Developing a CR Execution Guideline

This section shows the final proposal based on the adjustments and suggestions collected from stakeholders based on the validation step presented in the pilot CRs.

Figure 11 shows the final proposal structure for the CR execution guideline.

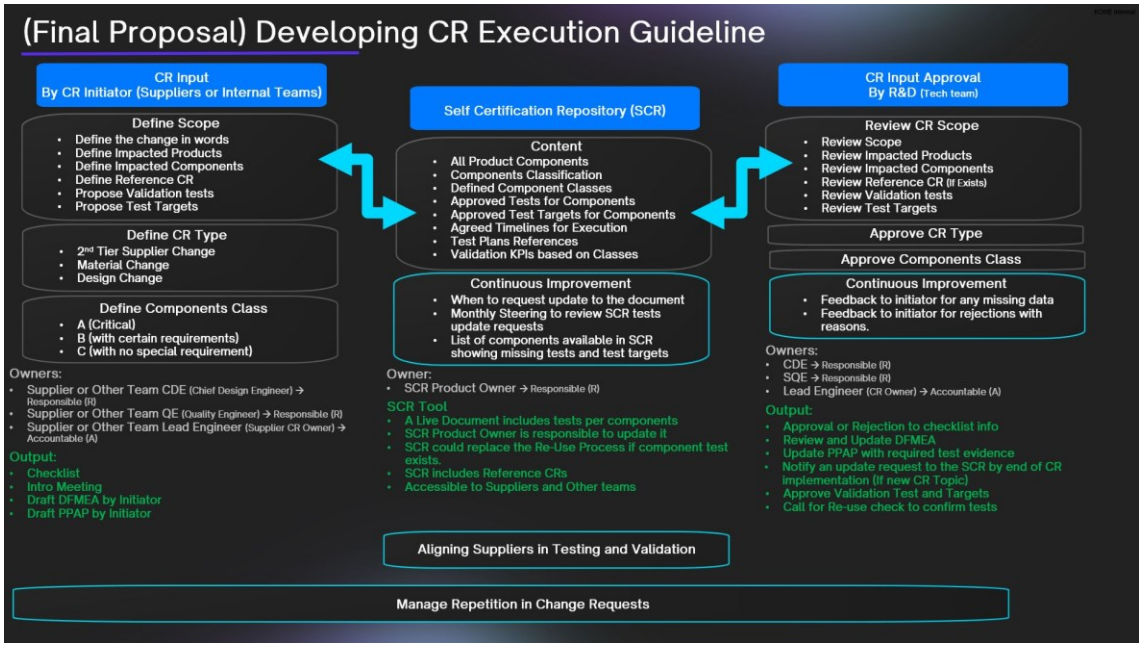

Figure 11. The final proposal for the CR execution guideline structure.

As outlined in the figure detailing the final proposal for the CR execution guideline, certain suggestions were reconsidered following stakeholder feedback and observations from the pilot CRs. The stakeholders decided against implementing a light version of the CR process.

This decision was based on concerns that relying solely on suppliers testing and validation measures might compromise the safety, as evidenced during the pilot phase. Additionally, it was unanimously agreed to retain the re-use check step within the CR process. This step continues to serve as a checkpoint, ensuring that all necessary tests and targets are included and that no additional requirements are overlooked.

7 Discussion and Conclusions

Section 7 is the final section of this study which includes the executive summary of the study, practical next steps, a self-evaluation of thesis project credibility, and the closing words.

7.1 Executive Summary

The huge amount of time consumed to execute a CR has impacted the R&D execution KPIs in terms of cost and team utilization due to the absence of gates to check whether the CRs have been executed before or not. Moreover, due to the lack of teams and supplier alignment. The level of information received from the CR initiators is not clear enough to provide an adequate amount of data to correctly identify the CR nature and topic. Despite the highly experienced team members in the R&D department, the transfer of knowledge might require more improvement. Accordingly, the objective of this study is to develop a guideline for the CR execution process to improve the time wasted in defining the scope and targets of testing and validation activities. The outcome is the CR execution guideline.

The applied action research approach is chosen for this study as it is suitable for projects that tackle an existing business issue that requires a solution for managers and stakeholders. The research consists of four stages starting with the current state analysis where an an overview of the current change request process is provided. It also identifies patterns, problems, and factors influencing it, and presents strengths and weaknesses. This stage involved internal and external stakeholders such as R&D team members, quality engineers, and one supplier. Data regarding the strengths and weaknesses were collected through individual interviews and workshops.

The main strengths are the powerful tools and approval gates, and the main weaknesses are the one CR execution process, misalignment with suppliers in testing and validation definitions and targets, and consuming a significant portion of time on repeated CRs.

Accordingly, the second stage commenced with the knowledge of the main weaknesses to define improvement areas and best practices from literature where the outcome of the stage was the conceptual framework that comprises the improvement areas to focus on for solving the existing problems defined during the current state analysis stage.

The third stage commenced using the inputs from the first and second stages, seeking to develop the initial proposal of the CR execution guideline. This was co-created by the team suggestions and based on the ideas collected from the literature.

The initial proposal mainly focuses on ensuring the level of information given by the CR initiator to correctly define the CR scope, it also introduced classes and types for the CR based on the criticality and the type of change.

Then it stresses on the validation of the CR input which is the scope by having an approval gate to ensure the level of details.

The proposal also introduced the self-certification repository which is a live document that aims to include all tests and test targets for all product components. This document aids in accelerating the process of defining tests for various components using previous CR, having all this data in one place assures that all team members have access to the data. This helps to avoid consuming time on defining tests and test targets for repeated topics.

The initial proposal was validated by the executive team using 3 pilot CRs where some of the suggested features were excluded from the proposal.

The final proposal of the guideline was implemented as planned in April 2024.

The guideline implemented does not change the CR execution process in terms of steps of execution. However, it helps to accelerate the process on the operative level within specific steps such as project scope, re-use check, PPAP, and DFMEA.

7.2 Practical Next Steps and Recommendations

This Section provides several recommendations to improve the Case Company CR execution process based on the study carried out starting from the Current State Analysis and down to the Final proposal of the CR Execution Guideline. These recommendations seek to improve the CR Execution Process.

1. Continuous Change Request Pilot Testing:
   Pilots should continue testing more varieties of CRs to guarantee the strength and applicability of the rules. This continuous validation procedure assists in pointing out any gaps and also helps to modify the rules as needed, these pilots must include a range of situations and different components.
2. SCR Expansion:
   At the moment, the SCR, which includes more than 3000 components, offers 15% to 20% of the tests required for the validation process. This

repository has to be constantly expanded to enlarge the SCR usefulness and improve its influence on the CR process by increasing the number of approved tests. A greater knowledge base from the addition of more tests and connecting it to the corresponding reference CRs enables a faster and more precise flow of the test definition process.

3. Addressing Suppliers Quotation Challenges:
   The Case Company suffers from a quotation validation problem with its suppliers. In other words, it was difficult to define the amount of work needed for the validation and testing activities for certain components. Accordingly, an extension of the guideline to include an estimate of the amount of work per task per CR was proposed to provide more beneficial information for supplier offer validation.
4. The Light CR Process:
   The idea of introducing a new Light CR process that would simplify the CR execution process was first discussed during the initial CR execution guideline stage but not approved during the piloting stage as it failed to define the right test requirements. Accordingly, it was decided to exclude from the final proposal.
5. Certification Associations Test Alignment:
   It is recommended to take into account the impact of the modifications on various categories of standards certifications. Adding this information enhances the value of the document. By engaging third-party certifying bodies, the guideline can be aligned with industry standards and best practices, promote greater acceptance of the modifications, and provide additional insights.

Reintroducing this idea with improved controls and monitoring could be advantageous considering the continuous difficulties and changing character of CR management. Strict documentation needs should be part of this procedure to guarantee traceability and transparency.

7.3 Self-Evaluation of Thesis Project Credibility

This study has utilized the applied action research approach to solve the business challenge by developing the CR execution guideline. This guideline serves to spot the repetition in the executed CR and benefit from the historical data from the previously executed CRs. Besides formal alignment internally and externally for test scopes and test targets. The guideline was co-created with the relevant stakeholders and validated through the piloting stage by the management team. The outcome is the final proposal for the CR execution guideline improved to solve the business problem.

7.3.1 Validity

Validity is considered to be the most crucial criterion for research as it defines the integrity of results drawn from a research study. Internal validity refers to determining whether a conclusion that includes a causal relationship between two or more variables is valid. If we propose that x is the cause of y, can we confidently assert that x is solely responsible for the variability in y, and not due to any other factors. (Bell et al., 2019)

To ensure the validity of the study, it was necessary to utilize multiple sources of information and trustworthy resources for exploring the current state analysis, and implementing the conceptual framework till the development of the initial and final CR execution guideline. Data is collected via stakeholder interviews, workshops, and pilot feedback. understanding of the present situation. The influence of the guideline on the existing process directly impacted the timeline and supplier behavior in favor of solving the business problem.

7.3.2 Reliability

Reliability is concerned with whether a study results can be replicated. The phrase is widely used to refer to the consistency of metrics used to assess business and management principles such as teamwork, employee motivation, and organizational effectiveness (Bell et al., 2019).

The final proposal of this study was based on data collected in different stages starting from the current state analysis, literature, and suggestions for the initial proposal, the data sources were different and based on the stage, such as interviews, workshops, literature review, and pilot feedback, where the core team hasn't changed during the study.

The final proposal was tested with actual existing CRs during the piloting stage and it was granted to be applicable. Moreover, the results are consistent.

7.3.3 Credibility

Establishing the credibility of findings involves both ensuring that research is conducted according to the guidelines of good practices and research findings from various sources to the members of the core team who were studied for confirmation that the investigator correctly understood that social world. this approach is known as triangulation (Bell et al., 2019).

Triangulation is the use of various techniques or sources of data in the study of social issues. The triangulation concept is derived from navigation and military strategy, where it refers to the practice of using numerous reference points to determine an object precise position. This approach is used more broadly to describe an approach that uses multiple observers, theoretical views, sources of data, and procedures, but the focus has tended to be on research methods and data sources (Bell et al., 2019).

During the various data collection stages, stakeholders were selected to cover all change request possible topics in terms of the technical experience required

to close the change request. Accordingly, the interview output ensured the concept of triangulation.

7.3.4 Relevance

The outcome of this thesis is to develop a guideline for the change request execution procedure, designed to be highly aligned with the organization short-term and long-term strategic objectives. Utilizing an input checklist and a Self Certification Repository which is a live document comprised of all testing scopes and test targets for all product sub-components, the newly established guideline improves operational efficiency by minimizing errors, reducing redundant work, and minimizing team utilization. It is anticipated that these enhancements will reduce operational expenses related to testing and engineering costs associated with CR management through the elimination of unnecessary repetitions. Although the guideline presents considerable prospective advantages, it also entails certain risks. Primarily, the SCR requires a deployment phase before attaining its full effectiveness. Proactive management is required to prevent the SCR from being abandoned or neglected, as this would compromise the advantages of the new guidelines.

7.3.5 Transparency

Researchers systematically document their research decisions and activities in an audit trail. The audit trail evaluates the credibility of the findings by examining the investigation procedure and outcome. It is frequently employed in academic papers, including dissertations. Verifies the documentation to ensure that the conclusions drawn are based on the data, that inferences are logical, that the structure of categories is suitable, and that the researcher degree of bias is taken into account. This procedure enhances the credibility of the narrative account (Creswell and Miller, 2000).

Practices and improvement ideas collected from the literature were logical to the topic of the study and the sources were relevant to the extent that supported the objective of the study.

For this study, the core team, members of the workshops, and interviewees were selected based on how relevant they were to the purpose of the study, the business problem, and the objective. Data collected throughout this study was recorded and reviewed.

7.4 Closing Words

This study aims to improve the time consumed to execute a change request received by the R&D department from internal or external stakeholders. Since the beginning of the study, and early during the current state analysis, improvement opportunities were clear. However, in the advanced stage of the study, the benefits of having a guideline to serve the main objective were touchable. Starting with the initial proposal of the guideline, then the validation using pilots helped to secure an applicable and practical guideline that serves the change request execution process and ensures its efficiency.

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Current State Analysis Interviews Questions and Workshop

Questions Arranged for the Supplier Quality Engineer interview:

- **Question 1:** What are the main problems causing delays to CR execution from the quality point of view?

  Summary of the answer: The main problems are directed towards the understanding of the supplier to the KPPAP requirement. Also, the fulfillment of the supplier to the evidence package requested after performing a test or after changing a process.

- **Question 2:** What documents are received from the supplier during the process execution?

  Summary of the answer: Depending on the scope of the CR, the main documents are, PPAP, DFMEA/PFMEA. Work instructions could also be requested, and some evidence based on the scope of the CR and/or the type of testing.

- **Question 3:** What is the supplier response rate for quality requests?

  Summary of the answer: The response rate is in the accepted levels. However, the problem is more related to the understanding of the requirements to avoid additional meetings or emails.

- **Question 4:** What are the recommendations to improve?

  Summary of the answer: the recommendation is to involve the supplier in the early stages during the preparations of the PPAP and by creating more simplified versions of the quality documents based on the scope of the CR.

Questions Arranged for the Supplier Interview:

- **Question 1:** What are the primary challenges encountered during the CR execution process?

  Summary of the answer: The answer was mainly related to the long lead time the case company requires to define test targets and testing scope, the repetition of the tests due to misalignment, the delay to approve the CR offers, and the team availability to execute more CRs during the quarter.

- **Question 2:** Which parts of the procedure do you believe are taking up unnecessary time?

  Summary of the answer: Testing scope definition, and CR offer approval.

- **Questions 3:** Are there any phases in the process that may be removed or simplified to shorten the overall execution time?

  Summary of the Answer: More alignment on the testing scope could accelerate the CR activities, especially when defining the testing scope.

  Also, some CRs might not need to go through the entire CR process due to the low risk and criticality of the component.

- **Question 4:** What are the recommendations to improve?

  Summary of the answer: the CR Process to include a light version of the CR execution process for less risky components, while agreeing on the criteria of defining the criticality and risk level of the component under test from quality and safety points of view.

Current State Analysis Workshop MoM:

Innov WS II Topic No#2: Current State Analysis of the CR process

Wednesday, January 17, 2024 9:00 AM

Date Wed 17 Jan 2024 (09:00-11:30)
Meeting Objective Discuss the current State Analysis of the CR Execution Process. (Study to improve the CR execution process)
Participants Core Team
Meeting Notes *Statements (S) Decisions (D) Actions (A) Questions (Q)*

(Q) CR execution process application?
- (S) The execution process is applied for all CRs.
- (S) The process is clear but still new for new team members.
- (S) PDM controls the whole process.
- (S) Disregarding the CR scope, the whole process is applied.
- (S) Based on Alignment with Wittur, C4 & C5 and/or C3 gates are merged.

(Q) What are the CR process pain points?
- (S) Misalignment with Supplier.
- (S) The supplier starts the tests without approving the testing scope or targets.
- (S) Define internal testing scope and test targets.
- (S) Offer Delay. --> (A) PO to Include in the Operational Steering
- (S) Reliability Targets and Testing Scope.
- (S) Challenges in arranging reuse checks.
- (S) Offer approval delay due to offer validation tools. --> (D) Sourcing to support -->(A) CR leader to present to Sourcing
- (S) Repeating the process for the same topics. (Hard to find the previously executed CR)
- (S) Alignment with platforms on the release dates for new change requests.
- (S) After CR PDM structure update --> (A) projects lead needs more attention

(Q) What are the key Strengths of the process
- (S) Archiving tool
- (S) Logic execution process
- (S) distributed responsibility (Gate approval)
- (S) Rellab tools (testing Facility)

(Q) During the CR execution process, what are the communication challenges internally and externally?
- (S) Internally, Nothing Major, minor alignment issues with Sourcing and platforms.
- (S) Externally, Supplier delay to feedback (ping pong emails)
- (S) Externally, the Scope description is poor and requires more attention from the supplier.
- (S) Certification body lack of response --> (D) Ali is the focal point. --> Ali to communicate the pending point to NoBo.(Notified body)

(Q)Do you consider checking the lessons learned?
- (S) In case of some history about the topic (Same project lead)
- (S) Archived with each CR, not in a commonplace.

(Q) Do you participate in pointing out lessons learned for each CR?
- (S) Yes (3 out of 5)

(Q) What tools do you normally use during the CR execution?
- (S) PDM, Windchill, Reuse & PPAP

(Q) What are the recommendations to improve?
- (S) Lessons learned in one shared file.
- (S) Timeline for offer sharing by the supplier
- (S) Feedback policy with the supplier.
- (S) Involve supplier in the reuse check --> (Q) is it a violation?

(Q) What documents do you normally use during the CR execution?
- (S) KPPAP, DFMEA, PFMEA, Technical Drawings, lessons learned template.

(Q) Are there any phases in the process that may be removed or simplified to shorten the overall execution time?
- (S) No

The Initial & Final Proposal for Developing the Guideline Workshop and Interviews

The initial proposal Workshop MoM:

Innov WS II Topic#3: Initial Proposal for developing CR execution guideline

Thursday, March 14, 2024 1:00 PM

Date Wed 14 Jan 2024 (13:00-15:00)
Meeting Objective Discuss the Initial Proposal for developing CR execution guideline
Participants Core Team
Meeting Notes *Statements (S) Decisions (D) Actions (A) Questions (Q)*

Initial proposal based on improvement ideas collected from CSA and CF

- Gate Checking for Repeated CRs
  - Checklist to define the CR scope to be shared by the supplier --> (A) Ali to collect the proposed items of the checklist from the team.
  - Input validation of CR initiator by the team to ensure the level of information provided.
  - Supplier to define whether the CR is a design change, a material change, or a sub-tier supplier change --> (A) Ali to align with the supplier regarding the new requests
  - Supplier to check (when possible) if this CR was repeated before by providing a reference CR.--> (A) Ali to share with the supplier
  - Request the supplier to implement a CR database --> (A) Ali to share with the supplier
  - CR steering meeting to review blockers and to discuss general improvement topics --> (A) Ali to share with the supplier

- One CR Execution Process. --> (A) Ali to agree and discuss with the supplier
  - Skip parts of the execution process in case repeated topics
  - Use Reference CRs to define test scopes and test targets
  - Create CR Classification --> a draft already exists, the supplier will share and the core team will review --> (A) collect and share confirmation to the supplier
    A (Critical)
    B (with certain requirements)
    C (with no special requirement)
  - Create a light version of the CR process (Related to the first point)
    - Exclude the reuse check step
    - Supplier to define the test in case CR is class C
  - Create a light version of the quality documents
    - Already discussed this with SQE and parts of the PPAP will be excluded for the light version (D) needs to be piloted before final approval. --> (A) Ali to collect and share with supplier

- Supplier Validation and Testing Process Alignment --> (A) Ali to align with the supplier once ready
  - Create a self-certification repository as a database for previously defined tests and validation methods
    - Mechanical expert + electrical expert + projects lead + supplier will draft the first version based on the supplier list of components and their corresponding tests and test targets.
  - Involve supplier in testing and validation process definition
    - Will be involved in setting up tests for the self-certification repository.
- Continuous improvement after CR execution --> (A) Ali to align with the supplier once ready
  - Allow continuous improvement to the previously approved validations and tests within the SCR
    - The Supplier can access the self-certification repository and has the right to request updates to tests based on mutual agreement between both parties.
    - Monthly steering to be arranged to discuss CR blockers and approve or discuss changes to the self-certification repository

The above suggestions should be piloted first before giving the green light. The product owner will propose CR(s) for pilots

Questions Arranged for the Supplier Quality Engineer interview:

- **Question 1:** Based on the below improvement areas, what are your suggestions for improvement? (one improvement area was removed as not relevant to the interviewee)

  Summary of the answer:

  - **One CR execution process:** A light version of the quality documents required by the supplier quality control team is already drafted and could be tested to accelerate the process based on the scope of the CR
  - **Alignment regarding testing scope and validation activities:** Involve the supplier in the draft releases of PPAP and DFMEA could minimize the wasted time sending emails and conducting meetings.

Questions Arranged for the Supplier Interview:

- **Question 1:** Based on the below improvement areas, what are your suggestions for improvement?
  Summary of the answer:

  - **Gate checking for repeated CRs:** Suppler agreed to check if the scope of the CR is repeated based on their internal system, share this information with the case company at the scope definition stage, and provide the CR number.
  - **One CR Execution process:** The supplier proposal is to have a simplified CR process for less critical components, where no design change is presented and the components involved are not impacting the safety or quality of the operation. It was agreed to provide feedback after reviewing with the rest of the stakeholders.

- **Supplier Validation and Testing Process Alignment:** Concerns were shared regarding starting testing and validation activities before a formal alignment with the case company and how this has impacted the process and the timeline of the CR, and it was agreed to align first before starting any test even if the CR process hasn’t started or targeted to start in the future.
- **Continuous improvement after CR execution:** The supplier proposed to conduct a periodic retrospective meeting to review what went well and what could be improved for a pre-defined list of CRs.

The final proposal MoM:

Final Proposal for developing CR execution guideline

Wednesday, April 10, 2024 10:00 AM

Date Wed 1o Apr 2024 (10:00-11:00)
Meeting Objective Discuss the final Proposal for developing CR execution guideline based on the Pilots
Participants Core Team + SQE + Supplier QM
Meeting Notes *Statements (S) Decisions (D) Actions (A) Questions (Q)*

- Pilot results:
  - CR- Pilot 1
    Base Duty Motor Supplier Change
    Class A (Critical Component)
    Available In SCR
    Validation Test and Test Targets defined and Approved in 15 days
    Conclusion: CR Duration improved by more than 75%

    CR- Pilot 2
    Motor Belt Material Change
    Class B (Certain Specs)
    Available In SCR
    Validation Test and Test Targets defined and Approved in 14 days
    Conclusion: CR Duration improved by more than 65%

    CR- Pilot 3
    Sync Hook Press Nut Design Change
    Class C (No Special Specs)
    Not Available
    Validation Test and Test Targets defined by Supplier in 3 days
    Conclusion: Not improved: Test Definition Improved. However, the test reports received should that the supplier is not stressing the press nut according to the requirement, also number of samples used for testing was not enough according to team experts.

The final proposal based on improvement ideas collected from CSA and CF and the pilot feedbacks

- Gate Checking for Repeated CRs
  - Checklist to define the CR scope to be shared by the supplier (Done)
  - Input validation of CR initiator by the team to ensure the level of information provided. (Done)
  - Supplier to define whether the CR is a design change, a material change, or a sub-tier supplier change (Done)
  - Supplier to check (when possible) if this CR was repeated before by providing a reference CR. (Done)
  - Request the supplier to implement a CR database. (Already exists)
  - CR steering meeting to review blockers and to discuss general improvement topics. (scheduled)
- One CR Execution Process.
  - Skip parts of the execution process in case repeated topics (No go based on pilot CR 3)
  - Use Reference CRs to define test scopes and test targets (Done)
  - Create CR Classification (Done for some components, the rest will follow)
    A (Critical)
    B (with certain requirements)
    C (with no special requirement)
  - Create a light version of the CR process (No go based on pilot CR 3)
    - Exclude the reuse check step
    - Supplier to define the test in case CR is class C
  - Create a light version of the quality documents (No go based on pilot CR 3)
    - Already discussed this with SQE and parts of the PPAP will be excluded for the light version (D) needs to be piloted before final approval.
- Supplier Validation and Testing Process Alignment.
  - Create a self-certification repository as a database for previously defined tests and validation methods. (Done)
    - Mechanical expert + electrical expert + projects lead + supplier will draft the first version based on the supplier list of components and their corresponding tests and test targets.
  - Involve supplier in testing and validation process definition (Done)
    - Will be involved in setting up tests for the self-certification repository.
- Continuous improvement after CR execution.
  - Allow continuous improvement to the previously approved validations and tests within the SCR (Done)
    - The Supplier can access the self-certification repository and has the right to request updates to tests based on mutual agreement between both parties.
    - Monthly steering to be arranged to discuss CR blockers and approve or discuss changes to the self-certification repository (Scheduled)

Change Request Execution Guideline:

CR input checklist and Approval:

CR input Checklist		Ownership	Comments	Approval/Feedback	Comments	Ownership	Instructions
Scope		Supplier project Lead				Project Lead	Describe the scope in words
Reason of Change		Supplier project Lead				Project Lead	Purpose of the change, eg. Cost reduction
Impacted products		Supplier project Lead				Project Lead	Include all impacted families eg. AMDSL2
Impacted Components		Supplier project Lead				Project Lead	Include all components (If many, use a separate sheet)
Reference CR		Supplier project Lead				Project Lead	If possible
Proposed Validation Test		Supplier Design Engineer/Project Lead				Project Lead	State if based on SCR or not
Proposed Test target		Supplier Design Engineer/Project Lead				Project Lead	State if based on SCR or not
Impacted Drawings		Supplier Design Engineer/Project Lead				Project Lead	Include all components (If many, use a separate sheet)
Impact the unit prices (Yes/No)		Supplier project Lead				Project Lead	
Impact to CTQ (Yes/No)		Supplier Design Engineer/Project Lead				Project Lead	
Impacted Volumes		Supplier project Lead				Project Lead	Mandatory for Business case, estimate should be okay in the early stages
Impacted region		Supplier project Lead				Project Lead	Mandatory for Business case, estimate should be okay in the early stages
CR type							
2nd Tier Supplier Change	☐	Supplier Design Engineer/Project Lead				Project Lead	Provide Name of the supplier
Material Change	☐	Supplier Design Engineer/Project Lead				Project Lead	Datasheet for both old and new materials and mention if fire test is required or not
Design Change	☐	Supplier Design Engineer/Project Lead				Project Lead	Share Draft drawings
Other	☐	Supplier Design Engineer/Project Lead				Project Lead	
Components Class							Based on the approved criteria
A (Critical)	☐	Supplier Design Engineer/Project Lead				Project Lead	
B (with certain requirements)	☐	Supplier Design Engineer/Project Lead				Project Lead	
C (with no special requirement)	☐	Supplier Design Engineer/Project Lead				Project Lead	
Other	☐	Supplier Design Engineer/Project Lead				Project Lead	
Documentation							
DFMEA	☐	if No, why? Supplier Quality Engineer				SQM	
PFMEA	☐	if No, why? Supplier Quality Engineer				SQM	
Gage R&R	☐	if No, why? Supplier Quality Engineer				SQM	
PPAP	☐	if No, why? Supplier Quality Engineer				SQM	
AAR	☐	if No, why? Supplier Quality Engineer				SQM	
Control Plan	☐	if No, why? Supplier Quality Engineer				SQM	

CR Classes:

1) Class A:
a. Safety components' core parts.
Damage, failure, malfunction, or premature deterioration of the part or assembly can lead to harmful situations. The safety component no longer functions properly.
Passengers and service installation personnel may face harm.
eg. Xxxxxx
b. Critical components for reliability
In the event of damage, failure, malfunction, or early deterioration, the part or assembly's dependability and quality are no longer guaranteed. While a call-out may not cause significant harm, it might result in costly callbacks and a terrible reputation.
c. Parts, defined as critical deriving from D.-FMEA
d. Safety components (assemblies)
2) Class B:
a. Parts requiring higher dimensional accuracy, materials, and production processes
e.g. Xxxxxx
b. Non-safety critical assemblies
e.g. Xxxxxx
3. Class C:
a. Parts without any particular needs
Even if a component is not designated as an essential component, it must meet all specifications and standards outlined in the part drawings.

Self Certification Repository

Appendix removed