Ratio Project Planning: product cost optimization projects in the production phase

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***Ratio Project Planning*: projetos de otimização do custo do produto na fase de produção**

Resumo

Os mercados estão a viver momentos de grande transformação. Com a globalização e com o avanço da tecnologia, os clientes exigem cada vez mais dos seus fornecedores que procuram afirmar-se em mercados cada vez mais competitivos. É o que ocorre no setor automóvel, caraterizado por um ambiente muito competitivo com margens reduzidas. Neste contexto, a redução de custos, sem comprometer a qualidade e a funcionalidade dos produtos, é uma questão estratégica para as empresas.

Esta investigação centrou-se no estudo de projetos de otimização do custo do produto aplicados na fase de produção suportados numa abordagem *lean management*. Estas empresas procuram reduzir o desperdício e otimizar os custos na fase de conceção e desenvolvimento do produto, continuando este esforço de melhoria contínua na fase de produção. A metodologia investigação-ação foi utilizada para identificar e compreender possíveis oportunidades de melhoria associadas aos vários procedimentos executados pela empresa em estudo ao nível do *Ratio Project Planning* (RPP).

A primeira sugestão de melhoria é a descrição do processo de RPP através da ferramenta VSDiA. Após a descrição e análise do processo, foram encontradas oportunidades de melhoria que permitem a otimização deste processo de redução de custos na fase de produção, principalmente a redução do tempo associado aos projetos implementados com vista à redução dos custos, o que resultará num aumento do lucro da empresa.

Depois, a fim de simplificar o acesso aos dados, facilitar a análise da informação e controlar com precisão os resultados do processo RPP, foi desenvolvido um *dashboard* em *Power BI*, contendo os indicadores-chave de desempenho para o acompanhamento de cada projeto, e a análise apresentada no relatório mensal. Esta ferramenta, além de melhorar a qualidade dos dados e permitir uma melhor gestão e tomada de decisão, resultou também em ganhos no que diz respeito ao tempo utilizado na realização do relatório.

Palavras-Chave

Cost Management; Kaizen Costing; Project Management; Ratio Project Planning; VSDiA

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ABSTRACT

Markets are experiencing moments of great transformation. With globalization and the advance of technology, customers demand more and more from brands that seek to assert themselves in increasingly competitive markets. This is the case of automotive sector, characterised by a very competitive environment with reduced margins. In this context, cost reduction, without compromising the quality and functionality of products, is a strategic question for companies.

This research focused on the study of product cost optimization projects applied in the production phase by a *lean management* approach. These companies seek to reduce waste and optimise costs in the product design and development phases and carry on with the continuous improvement effort in the production phase. The action-research methodology was used to identify and understand possible improvement opportunities associated to several procedures executed by the company under study at the *Ratio Project Planning* (RPP) level.

The first suggestion for improvement is the description of the RPP process through the VSDiA tool. After the description and analysis of the process, improvement opportunities were found that allow the optimization of the cost reduction process in the production phase, mainly the reduction of the time spent to implement the projects, which will result in an increase of company's profit.

Then, in order to simplify access to data, to facilitate the analysis of the information and to accurately control the results of the RPP process, a *dashboard* in *Power BI* was developed, containing the key performance indicators for the monitoring of each project, and the analysis presented in the monthly report. This tool, besides improving the quality of the data and allowing better management and decision making, also resulted in gains regarding the time used to perform the report.

KEYWORDS

Cost Management; Kaizen Costing; Project Management; Ratio Project Planning; VSDiA

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LIST OF ABBREVIATIONS AND ACRONYMS

BI – Business Intelligence

BU – Business Unit

CTG – Controlling

DFMA – Design For Manufacturability and Assembly

ECR – Engineering Change Request

HG – Hardness Grade

KC – Kaizen Costing

KPI – Key Performance Indicator

MAT – Material

MFE – Manufacturing Engineering

OPL – Open Point Lists

PMBOK – Project Management Body of Knowledge

PMI – Project Management Institute

PPC – Product Planned Costs

QFD – Quality Function Deployment

RPP – Ratio Project Planning

SG&A – Selling, General and Administrative costs

SOP – Start Of Production

TC – Target Costing

VA – Value Added

VE – Value Engineering

VSDiA – Value Stream Design in Indirect Areas

1. INTRODUCTION

This research is based on product cost optimization projects applied by companies that follow a lean approach. These companies seek to reduce waste from product design and development phases, focusing normally on the production phase (Afonso & Leite, 2016).

This chapter presents the background and motivation for this dissertation project, identifies the objectives of this research and, finally, the structure of the dissertation.

1.1 Background and motivation

Several markets are experiencing moments of great transformation. With globalization and the advance of technology, customers demand more and more from suppliers that seek to assert themselves in increasingly competitive markets. This is what happens in the transportation sector, particularly in the automotive market. The automotive sector is a very competitive market with low margins and it is natural that cost reduction, without compromising the quality and functionality of its products, is an obvious concern for companies (Baharudin & Jusoh, 2015). According to Michael Porter, one of the strategies for companies to prevail in competitive markets is the cost leadership strategy which consists of achieving lower costs than competition, with efficiency being a key factor (Tanwar, 2013). The practice of cost reduction should be part of company's culture and applied daily, however this requires some time, organization and sometimes some investments. On the other hand, the implementation of some improvements is often faced with conflicts and resistance, causing delays and difficulties in achieving the stipulated objectives (Himme, 2012). It is then necessary to involve the "top management", which facilitates the cost reduction implementation processes, when they agree and are convinced of the benefit of the proposed changes (Berk, 2010). Summing up, the success of cost reduction practices depends on the company's cost management culture, the commitment of top managers/administrators and the collaboration of all associates.

In general, when products are introduced in the market, they have high prices, but theses tend to decrease as the life cycle advances, especially in the technology sector. Therefore, companies must have adequate cost management systems and be prepared to implement cost reduction plans in order to maintain the desired levels of profitability (Bragg, 2010).

The cost reductions systems mentioned by Monden (2000) were based on standardized processes in the Japanese automotive industry that were improving these methods for several decades in the second half of the 20th century (Leite, 2013). These cost reduction systems follow the stages of a product's life cycle, in order to achieve the desired levels of profitability and they are differentiated according to the time of application. To manage costs during the development phase of a new product, Target Costing (TC) has emerged, and for the production phase emerged Kaizen Costing (KC). These two approaches are interconnected since KC is an extension of TC from the development phase to the production phase. Monden (2000) summarises the two concepts as follows. Target Costing is the system used to support the cost reduction process in the development phase of an entirely new model. This may be a new product or a complete change at the product level or a small modification in the product. On the other hand, Kaizen Costing is defined by Monden (2000) as a system used to support the cost reduction process in the production phase of an existing product. Japanese term "Kaizen" refers to cumulative improvement of repetitive activities rather than improvement by innovation. Improvement by innovation based on technological breakthroughs are usually introduced in the development phase. The two concepts combined form the basis of Total Cost Management.

Cost reduction is generally considered to be a very important activity in the modern management of companies. All managers, nowadays, are concerned and aware about this, but often, it is not possible to apply it in reality. In lean organisations, concerned with reducing waste and focused on optimising processes and maximising the value created for the organisation and the customer, there is the motivation to raise employees' awareness in order to find ways of optimising their activities and, consequently find ways to reduce costs. In this context, cost reduction should be considered as something much more than a mere individual and episodic practice, resulting mostly from a collective contribution. Thus, to reduce costs, many companies are opting to organise themselves in the form of a project, involving the necessary departments and employees to work towards a specific goal (of reducing costs). Currently, in most companies, the contribution of ideas that may justify the creation of these projects is encouraged, within the scope of continuous improvement. These projects go through distinct management phases, normally coordinated by a manager. It is an effective way of organising activities to achieve cost reduction objectives. To ensure the success of these projects, the team should be motivated and focused on the cost reduction, with clear tasks and responsibilities, and with all information available to all employees (Radner, 1975).

1.2 Objectives

This project seeks to analyse two main tasks performed by the Ratio Project Planning coordinator and improve them. The tasks are the coordination of product cost optimization projects and the elaboration of the RPP (Ratio Project Planning) monthly report.

Regarding the first task, the main goal is to map the process using a value stream mapping tool for indirect areas and then find opportunities for improvement.

Then, the following goal is to optimize the reporting of the RPP results, as it was completely manual and took a lot of effort to do it. It was therefore intended to develop a dashboard that included the performance indicators, presenting useful and relevant information to the RPP coordinator, thus allowing for more effective decision-making.

1.3 Dissertation structure

The dissertation is divided into six main chapters, namely introduction, literature review, research methodology, case study, analysis and discussion of the results and conclusions.

The introduction chapter seeks to present, in a general way, the concepts and topics under study, through a brief description of the background and the motivation. Also, in this chapter, the planned objectives are presented, as well as the dissertation structure.

The second chapter, regarding the literature review, clarifies concepts in terms of project management, such as the PMBOK (Project Management Body of Knowledge) overview and lean project management, and also the value stream design for indirect areas. On the other hand, in terms of cost management, this chapter focus on target costing and kaizen costing that will serve as theoretical basis for the following chapters. Finally, it also covers the business intelligence topic.

The third chapter refers to the research method used, action research, with a brief description of the method, as well as the steps involved in applying it to the project in question.

The fourth chapter describes the company where the dissertation was developed, referring to some important milestones in the history of the company, some current data, the different business sectors, and the organizational structure. This chapter also describes the current state of the RPP methodology and presents some proposals for improvement.

In chapter five, an analysis of the RPP methodology is performed comparing it with other methodologies presented in the literature review and the validations of the improvement proposals are presented.

Finally, the objective of chapter six is to highlight and synthesize the aspects achieved with the project, as well as the limitations and the opportunities for future research.

2. Literature Review

Throughout this chapter, a theoretical foundation is made on themes and concepts that were essential to the research, in order to clarify and deepen the scope in which this project was inserted. Therefore, this chapter is divided into three main topics. The first main topic, project management, covers an overview of the PMBOK and the lean project management approach, where VSDiA (Value Stream Design in Indirect Areas) is mentioned. The second topic is regarding cost management and here is introduced the target costing and the kaizen costing. Finally, an analysis was carried out on business intelligence topic.

2.1 Project management

The project management knowledge takes an important role on this research. According to multiple empirical studies, a company's effectiveness partly depends on the success of its projects (Patanakul & Milosevic, 2005). According to the Project Management Institute (2017), a project is a temporary endeavour undertaken to create a unique product, service, or result, whereas International Project Management Association (2015) says that a project is a time and cost constrained operation to realize a set of defined deliverables (the scope to fulfil the project's objectives) up to quality standards and requirements as it is shown in Figure 1.

Figure 1 – Project management triangle

2.1.1 PMBOK overview

Project Management has always been practiced informally but began to emerge as a distinct profession in the mid-20th century. PMI (Project Management Institute) published a manual entitled "A Guide to the Project Management Body of Knowledge (PMBOK® Guide)" to identify the recurring elements for project management process. The project management body of knowledge includes proven traditional practices that are widely applied, as well as innovative practices that are emerging in the profession (Project Management Institute, 2017).

The PMBOK was chosen for this research, not only because it is the standard guide used by the company, but also because it covers several areas of knowledge, and it is considered a great source of knowledge.

The Project Management Institute was formally incorporated in Commonwealth of Pennsylvania in 1969 with five volunteers in the field of project management working together to “advance the practice, science and profession of project management”. PMBOK® Guide is an acronym for “A Guide to the Project Management Body of Knowledge” and it is the most important publication by the PMI. After extensive consultation and revision, the PMBOK® Guide was published in 1996 to supersede the previous documents. They saw a need to put together an official document and guide to advance the development of the project management profession. This was known as the PMBOK® Guide 1st Edition. Since then, the PMI has been improving the methods developing six more Guides - PMBOK® Guide 2nd Edition [2000], PMBOK® Guide 3rd Edition [2004], PMBOK® Guide 4th Edition [2009], PMBOK® Guide 5th Edition [2013], PMBOK® Guide 6th Edition [2017] and PMBOK® Guide 7th Edition that will be released during 2021.

According to PMBOK® Guide 6th Edition, a project life cycle is the series of phases that a project passes through from its start to its completion. A project phase is a collection of logically related project activities that culminates in the completion of one or more deliverables (Project Management Institute, 2017).

The project management processes can be divided into five groups of processes, which are:

- **Initiating Process Group**. The process performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase.
- **Planning Process Group**. The process required to establish the scope of the project, refine the objectives, and define the course of action required to achieve the objectives for which the project was designed.
- **Executing Process Group**. The process performed to complete the work defined in the project management plan to satisfy the project requirements.
- **Monitoring and Controlling Process Group**. The process required to track, review, and regulate the progress and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes.

- **Closing Process Group**. The process performed to formally complete or close a project, phase, or contract.

These five groups of processes characterize a project life cycle and interact with each other, as shown in Figure 2 (Project Management Institute, 2017).

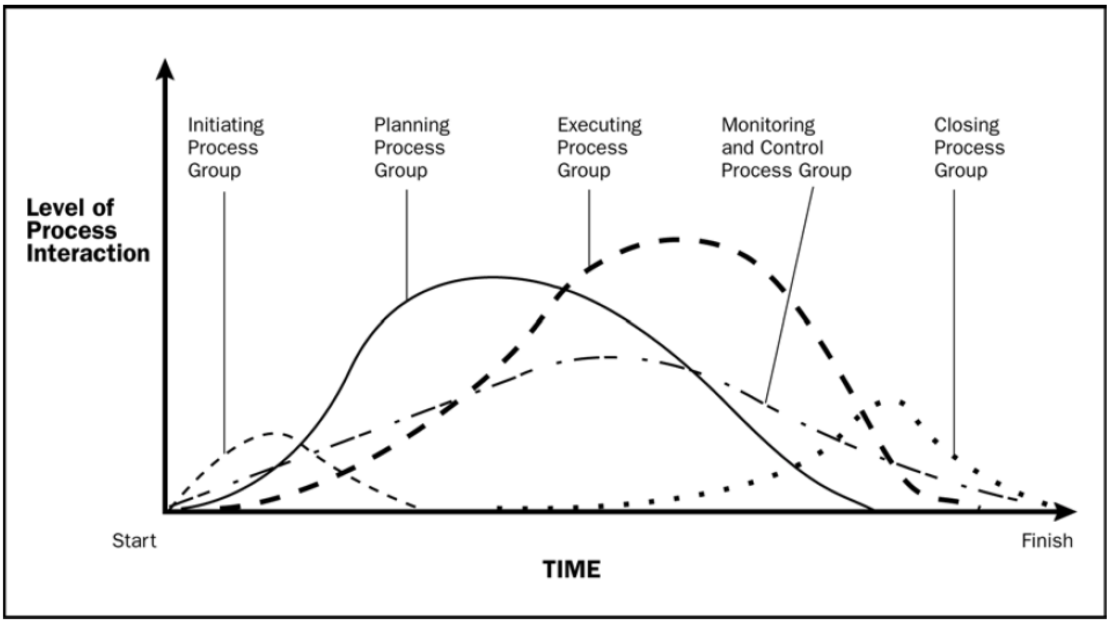

Figure 2 – Process groups interaction in a project

Regardless these five process groups, PMBOK, also establishes ten areas of knowledge for Project Management, which are (Project Management Institute, 2017):

- **Project Integration Management**: includes the processes and activities to identify, define, combine, unify, and coordinate the various processes and project management activities within the Project Management Process Groups.
- **Project Scope Management**: includes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully.
- **Project Schedule Management**: includes the processes required to manage the timely completion of the project.
- **Project Cost Management**: includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs, so the project can be completed within the approved budget.

- **Project Quality Management**: includes the processes for incorporating the organization's quality policy regarding planning, managing, and controlling project and product quality requirements, in order to meet stakeholders' expectations.
- **Project Resource Management**: includes the processes to identify, acquire, and manage the resources needed for the successful completion of the project.
- **Project Communications Management:** includes the processes required to ensure timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and ultimate disposition of project information.
- **Project Risk Management**: includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project.
- **Project Procurement Management**: includes the processes necessary to purchase or acquire products, services, or results needed from outside the project team.
- **Project Stakeholder Management:** includes the processes required to identify the people, groups, or organizations that could affect or be affected by the project, to analyse stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution.

Figure 3 illustrates all knowledge areas from the PMI, as well as all the processes that compose them. Each knowledge area can have processes from several process groups, such as each process group can cover multiple knowledge areas (Project Management Institute, 2017).

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work 4.4 Manage Project Knowledge	4.5 Monitor and Control Project Work 4.6 Perform Integrated Change Control	4.7 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Schedule Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Manage Quality	8.3 Control Quality	
9. Project Resource Management		9.1 Plan Resource Management 9.2 Estimate Activity Resources	9.3 Acquire Resources 9.4 Develop Team 9.5 Manage Team	9.6 Control Resources	
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Monitor Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses	11.6 Implement Risk Responses	11.7 Monitor Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Engagement	13.3 Manage Stakeholder Engagement	13.4 Monitor Stakeholder Engagement	

Figure 3 – Project Management Process Group and knowledge Area Mapping

(Project Management Institute, 2017)

2.1.2 Lean project management

After the success of the best-seller book, Womack, Jones and Roos (1990) received many requests from companies that want to know how to implement Lean production. To respond to these requests Womack & Jones (1996) published a second book named Lean Thinking, with the principles for companies to follow in order to implement Lean. Lean Thinking is the antidote to waste. It is a philosophy to achieve more with less (Jalali et al., 2016). This philosophy has five principles which are (Womack & Jones, 1996):

- **Identification of value** means that value is always defined by the customer's needs for a specific product. Only the ultimate customer can define value. It specifies the important requirements or expectations that must be met.
- **Value stream**: it is the mapping of all activities that identifies all the actions that take a product or service through any process, distinguishing the value-added activities from the non-value added.
- **Flow**: this step is made to be sure the remaining steps flow smoothly with no interruptions, delays, or bottlenecks.
- **Pull production**: it is deeply connected to the production, where the costumers pull the products, preventing the increase of stocks.
- **Pursuit perfection**: it is perhaps the most important, making Lean Thinking and process improvement part of a corporate culture.

Lean project management has many ideas in common with other lean concepts, however, the main principle of lean project management is delivering more value with less waste in a project context (Lloyd, 2013). Lean project management is the application of lean manufacturing principles to the practice of the management of projects (Moujib, 2007). Moujib (2007) concludes that the approach of the lean project management needs to perceive the projects as a value stream. Value stream mapping can be an important tool for project management processes improvement. Countless process mapping tools could be used to do this, however the company under study has designed a process mapping tool called Value Stream Design in Indirect Areas (VSDiA) (Abreu et al., 2017).

VSDiA

Value Stream Design in Indirect Areas (VSDiA) is a tool that was developed to enable process improvement and optimization (Etzel & Kutz, 2009). With VSDiA, non-value adding activities and non-necessary process steps become visible and its graphical presentation communicates the need for change. As the process important stakeholders are members of the VSDiA improvement team, resistance against change is previously foreseen and countermeasures implementation turns out to be easier. Process performance indicators are defined for each process to assess its efficiency and effectiveness, and these should be related to the function-oriented performance indicators. One of the most important performance indicators in processes improvement is the Lead Time. The total average Lead Time represents the total of the Transition Period, Query Time and Process Time. Each of them can be described as (Abreu et al., 2017):

- **Transition Period:** The time between the end of processing and further processing.
- **Query Time:** The average time taken by any returns that arise during the process. This time must be weighted by its relative frequency.
- **Process Time:** The required time to perform a process.

The VSDiA analysis uses the following visualization elements (Figure 4) (Silva, 2016):

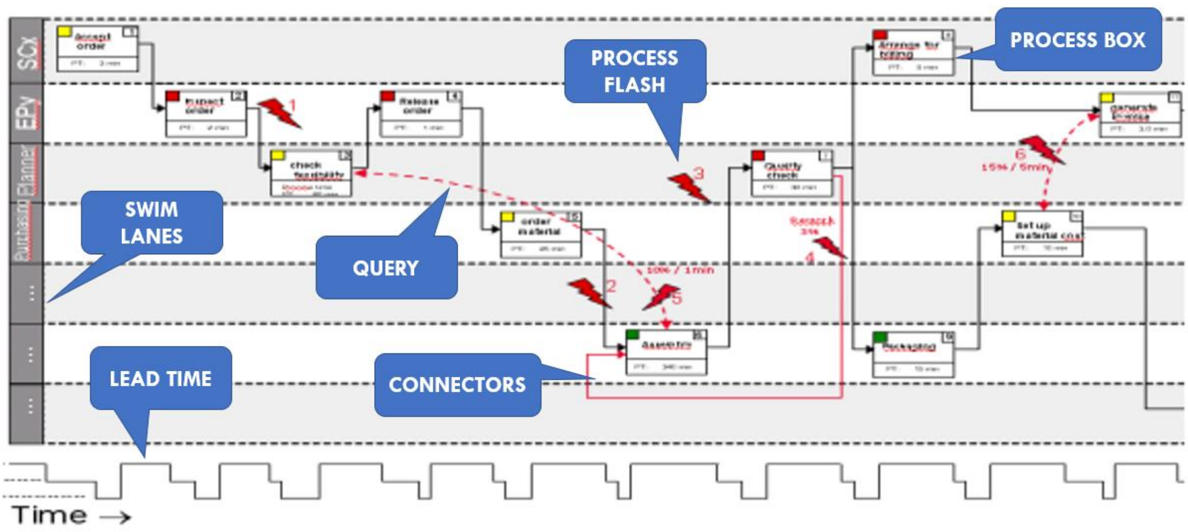

Figure 4 – VSDiA

1. **Swim lanes:** this swim lanes shows all the essential details. Each swim lane is affected to a role or function (Figure 5).

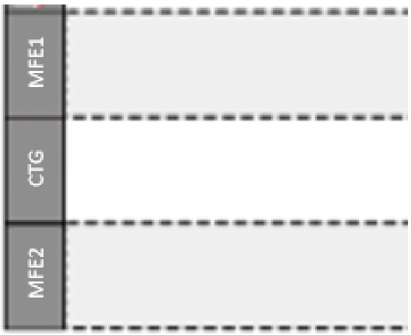

Figure 5 – VSDiA swim lane

2. **Process box:** the process boxes are documented, numbered in the upper right corner and identified as a value-adding activity (in green), a supporting activity (in yellow) or a waste (in red). Process time is the time the role or function requires to carry out the process step. The process boxes should be moved in into the role or function swim lane responsible for the activity (Figure 6).

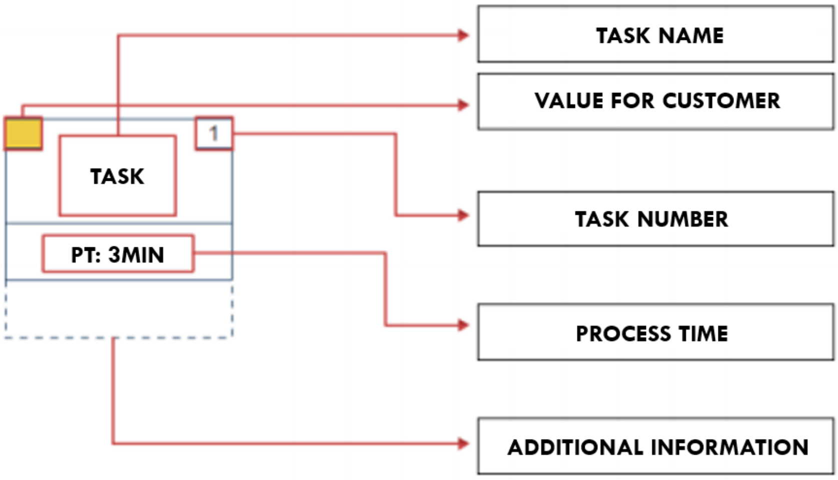

Figure 6 – VSDiA Process box

3. **Connectors:** process boxes are connected by arrows, the black ones indicate the process evolution in time, red arrows indicate returns and dotted red arrows indicate inquiries or questions. If the information can follow several paths, the frequency at which this occurs should be indicated on the connectors. The information transition time should also be represented on the connectors (Figure 7).

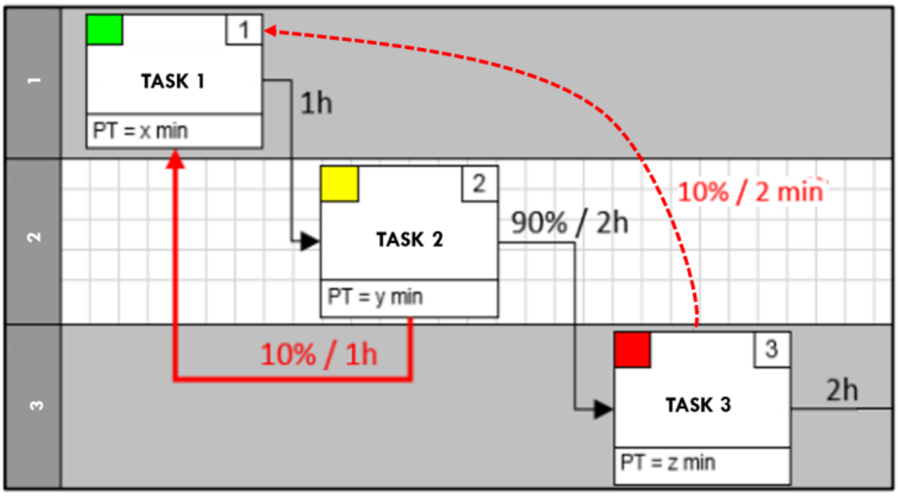

Figure 7 – VSDiA connectors

4. **Flashes and queries:** flashes are used to illustrate the identified problems that need to be answered. On the other hand, queries are dashed red vectors, representing incomplete information that must be inquired. Their existence will imply spending time questioning individuals to proceed with the process. A query is always associated with a flash (Figure 8).

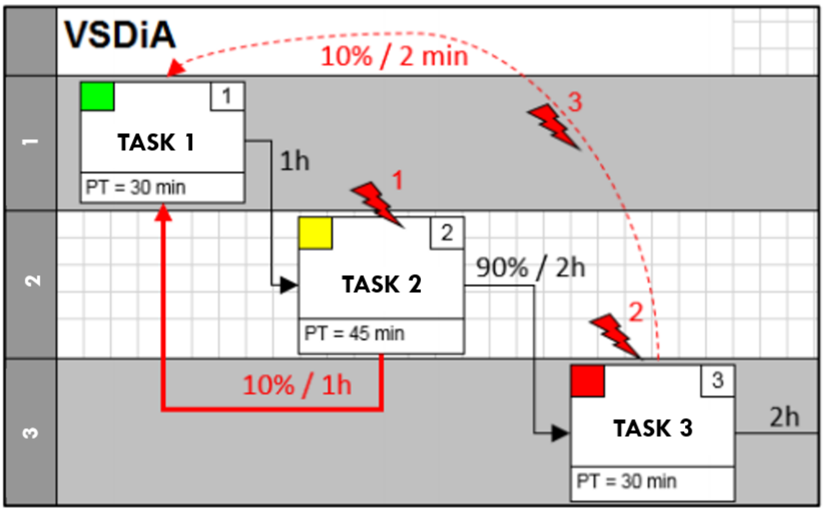

Figure 8 – VSDiA flashes and queries

5. **Temporal elements:** to calculate the throughput time of the process, it is necessary to calculate and add up the information transition time (T), processing (P) and query (Q) times (Figure 9). The first is how much time elapses from the end of the previous process to the beginning of the current process. In other words, it is the time that a task remains waiting to be processed. The processing time is the duration of the task. The query time

is how much time is spent asking questions to complete missing information or correct errors. To make the calculations, the frequency is considered.

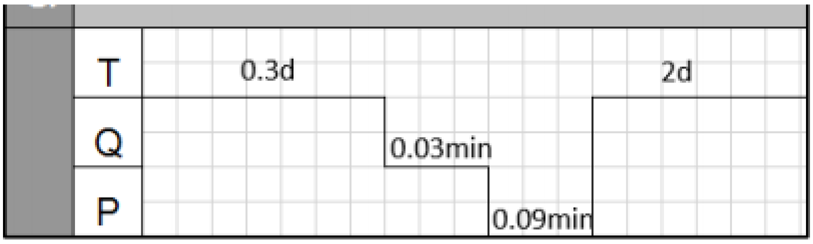

Figure 9 – VSDiA Temporal elements

Then, to structure a VSDiA project, four phases are necessary (Etzel & Kutz, 2009):

1. The **preparation** phase clears up the general process and boundary conditions, like where does the process start and stop, who is the customer and which roles/functions are involved. Users' engagement starts here, in this preparation phase. It contains three steps: orientation, project agreement and project work organization.
2. The **value stream analysis** phase contains three steps: definition of the subject under review, current state record and results follow-up. Thus, the process visualization as it is lived presently, will allow the identification of all disturbances and problems that happen.
3. The **value stream design** phase includes four steps: run detailed training on the background of Lean, develop the vision for the area or process, plan the target value stream, and measure and visualize the status and process performance. In this phase, besides creating a process that is oriented towards customer requirements, avoiding any waste since the beginning, a task list is also created in order to get from the current state process to the targeted one.
4. The last phase of **implementation** includes three steps: specify work and process standards, implement the necessary measures in order to get from the current to the target process and place standards into practice. The new process has to become the usual way of doing business and must be lived accordingly.

Some limitations of this tool are related with the high demand of resources (human and materials), such as the involvement of all attendees that requires time, an available schedule and space, as well as some visual boards and cards. Furthermore, it requires a previous, careful and time-consuming preparation, that must be organized by VSDiA experts, in order to ensure the proper conduction of the workshop and the compromise between all attendees. Additionally, a good relationship between the involved departments is necessary, otherwise, the expected workshop goals will not be achieved (Abreu et al., 2017).

2.2 Cost management

As it was mentioned above, cost management is one of the main pillars of Project Management. The cost management process begins in the planning phase of the project, where the costs are approved by executives before being implemented. Then, when the project is executed, the expenses are carefully monitored and recorded to make sure that they are aligned with the cost management plan. As the product prices theses tend to decrease as the life cycle advances, companies must have adequate cost management systems and be prepared to implement cost reduction plans in order to maintain the desired levels of profitability and stay within the budget (Bragg, 2010). Regarding cost reduction systems, target costing and kaizen costing are some of the bests known and will be explained below.

2.2.1 Target cost management

Target costing is a costing reduction system originated in Japan in 1960s. It remained a secret for some years, but by the 1980s target costing was widely recognised as one of the key factors in competitive excellence for Japanese companies. Many large companies in Europe and North America tried to adopt this system and thus many variants of target costing were developed and used in different countries (Al-Hattami et al., 2020).

Japanese firms believe the consumer will only buy the product if the price is less than the perceived value of the product. As such, there are only two ways to make this happen—increase the perceived value of the product or lower the price of the product by lowering the costs required to produce it (Monden, 2000). And this is where target costing appears. Target costing is fundamentally a strategic tool for cost management that enables costs to be reduced throughout the life cycle of a product, without reducing its quality, ensuring a certain margin in relation to the market price of the final product is achieved (Yoshikawa et al., 1994). Unlike standard cost control systems that are applied during the production phase, target costing is usually applied in the development phase of a new product. It is focused on not exceed the maximum allowable cost which is computed considering the product’s target price that the market accepts and the margin that the company intends to achieve for that product which should be aligned with the long term strategic planning of the company (Afonso & Leite, 2016). Therefore, by applying target costing, companies are ready to meet market needs through products at a competitive price while ensuring the best results in terms of profitability (Leite, 2013).

2.2.1.1 Target costing process

In order to implement target costing in a manufacturing firm and to determine the target costs for a product Ibusuki and Kaminski (2007) propose a process that is presented in the following figure.

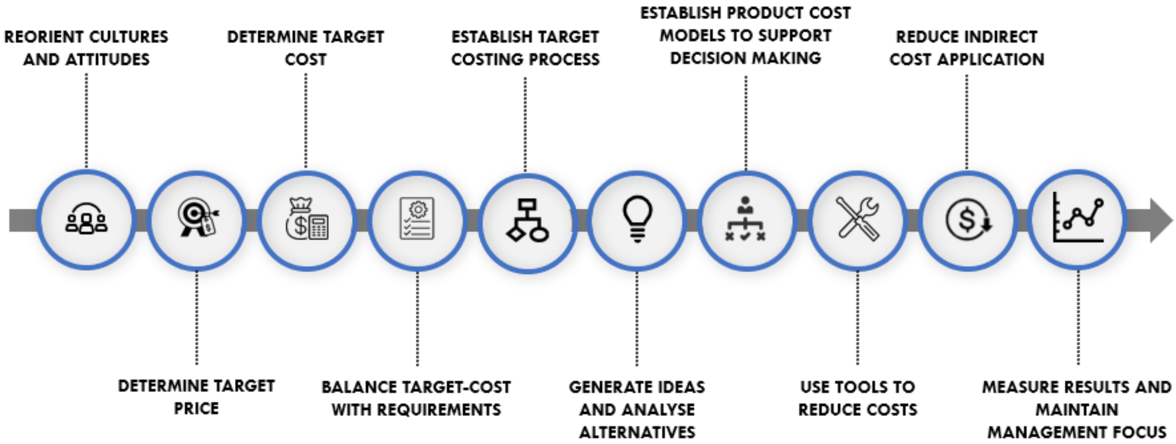

Figure 10 – Target costing process

As we can see the first step is **reorient culture and attitudes** and it is the most challenging step. The purpose of this step is to re-orient thinking toward market-driven pricing and prioritized customer needs rather than just technical requirements as a basis for product development. This is a fundamental change from the attitude in most organizations where cost is the result of the design rather than the influencer of the design and that pricing is derived from building up an estimate of the cost of manufacturing a product (Ibusuki & Kaminski, 2007).

The second step is **establishing a market-driven target price**. A target price needs to be established based upon market factors such as the company position in the marketplace (market share), business and market penetration strategy, competition and competitive price response, targeted market niche or price point, and elasticity of demand. If the company is responding to a request for proposal/quotation, the target price is based on analysis of the price to win considering customer affordability and competitive analysis (Ibusuki & Kaminski, 2007).

Then, the third step is **determining the target cost**. Once the target price is established, the calculation of target cost is obtained by subtracting the standard profit margin, warranty reserves, and any uncontrollable corporate allocations from target price. If a bid includes nonrecurring development costs, these are also subtracted. The target cost is allocated down to lower level assemblies of subsystems in a manner consistent with the structure of teams or individual designer responsibilities (Ibusuki & Kaminski, 2007).

The fourth step is **balancing target cost with requirements**. Before the target cost is finalized, it must be considered in conjunction with product requirements. The greatest opportunity to control a product's costs is through proper setting of requirements or specifications. This requires a careful understanding of the voice of the customer, use of conjoint analysis to understand the value that customers place on particular product capabilities, and use of techniques such as quality function deployment to help make these trade-off's among various product requirements including target cost (Ibusuki & Kaminski, 2007).

The fifth step is **establishing a target costing process and a team-based organization**. A well-defined process is required that integrates activities and tasks to support to support target costing. This process needs to be based on early and proactive consideration of target costs and incorporate tools and methodologies described subsequently. Further, a team-based organization is required that integrates essential disciplines such as marketing, engineering, manufacturing, purchasing, and finance. Responsibilities to support target costing need to be clearly defined (Ibusuki & Kaminski, 2007).

Then, the sixth step is **brainstorm and analyse alternatives**. This is the second most significant opportunity to achieve cost reduction is through consideration of multiple concept and design alternatives for both the product and its manufacturing and support processes at each stage of the development cycle. These opportunities can be achieved when there is out-of-the-box or creative consideration of alternatives coupled with structured analysis and decision-making methods (Ibusuki & Kaminski, 2007).

The seventh step is **establishing product cost models to support decision-making**. Product cost models and cost tables provide the tools to evaluate the implications of concept and design alternatives. In the early stages of development, these models are based on parametric estimating or analogy techniques. Further on in the development cycle as the product and process become more defined, these models are based on industrial engineering or bottom-up estimating techniques. The models need to be comprehensive to address all of the proposed materials, fabrication processes, and assembly process and need to be validated to ensure reasonable accuracy. A target cost worksheet can be used to capture the various elements of product cost, compare alternatives, as well as track changing estimates against target cost over the development cycle (Ibusuki & Kaminski, 2007).

Using tools to reduce costs is the eighth step. The use of tools and methodologies related to design for manufacturability and assembly, design for inspection and test, modularity and part standardization, and value analysis or function analysis (Ibusuki & Kaminski, 2007). Regarding these tools and methodologies, some of the most used and that are explained below, are the value engineering (VE), the design for manufacturability and assembly (DFMA) and the quality function deployment (QFD) (Leite, 2013).

- **Value engineering (VE)**

  Value engineering tool analyses the product cost structure in order to identify ways to change the design of the product in order to be manufactured at its target cost (Wouters et al., 2016). It optimizes value by considering the trade-off between product functions and their cost (Iranmanesh & Thomson, 2008). TC and VE are complementary processes because TC indicate the target cost and VE identifies where the cost reduction can be achieved (Ibusuki & Kaminski, 2007).
- **Design for manufacturing and assembly (DFMA)**

  The DFMA is a tool that allows to reduce costs making products easier to assemble or produce and keeping the product features at specified levels (Wouters et al., 2016)
- **Quality function deployment**

  This tool represents the "voice of the customer" throughout the product development (Kim et al., 2000). Product requirements must be considered before the target cost is concluded because proper configuration of requirements and specifications helps control costs (Ibusuki & Kaminski, 2007). Translate "the desires of the customer into product design or engineering characteristics, and subsequently into parts characteristics, process plans, and production requirements associated with its manufacture" using a "house of quality", which contains information on performance characteristics (what to do), engineering characteristics (how to do it), the integration of this information and benchmarking data (Kim et al., 2000). Used in operations management in order to understand customer requirements formulated in terms of required technical attributes (it displays the relationships between customer requirements and technical attributes through a matrix).

Almost at the end, the ninth step is **reducing indirect cost application**. Since a significant portion of a product's costs (typically 30-50%) are indirect, these costs must also be addressed. The enterprise must examine these costs, re-engineer indirect business processes, and minimize non-value-added costs. But in addition to these steps, development personnel generally lack an understanding of the relationship of these costs to the product and process design decisions that they make. Use of activity-based costing and an understanding of the organization's cost drivers can provide a basis for understanding how design decisions impact indirect costs and, as a result, allow their avoidance (Ibusuki & Kaminski, 2007).

Finally, the tenth step is **measure results and maintain management focus**. Current estimated costs need to be tracked against target cost throughout development and the rate of closure monitored. Management needs to focus attention of target cost achievement during design reviews and phase-gate reviews to communicate the importance of target costing to the organization (Ibusuki & Kaminski, 2007).

2.2.1.2 Benefits of target costing

Using target costing as a cost reduction technique can be beneficial in the following ways:

- **Cost optimization.** A primary advantage of target costing is that it allows you to analyse the best way to make or acquire products at the lowest costs. Minimizing costs is a common financial goal of any small business, regardless of whether they offer high, medium, or low prices. Minimizing costs gives a small company financial flexibility to focus on achieving high profit margins or to enter the market at low price points to attract a large customer base (Celestine & Ramuolumeni, 2019).
- **Systematic target costing** is a much more formal and systematic way to focus on cost optimization than other less-formal approaches often used by small businesses. It requires more time to go through a systematic approach like this, but the results are typically more fine-tuned. Target costing involves consideration of all equipment, processes, labour and materials needed to make goods, or the costs to acquire goods and get them ready to sell to your customers (Celestine & Ramuolumeni, 2019).
- **Reduced development cycle.** A point of emphasis in reducing costs with target costing is minimizing product cycle time. This is the amount of time it takes from conception to market-ready product. A reduced cycle time means you eliminate unnecessary steps or waste that take time and don't add value to the end solution for the customer. A shorter cycle time is a competitive advantage as well, since you can present your product to the market sooner, perhaps as the first mover (Celestine & Ramuolumeni, 2019).
- **Profitability.** If it is effective, target costing ultimately gives your business greater profitability. It considers both factors in profit: the costs and the price. Many companies start by developing products and base pricing on costs. By starting with market pricing

first, you help ensure that you end up with a product that has benefits, and a price point customer will value. In essence, you achieve the optimal price-to-cost relationship possible for your products (Celestine & Ramuolumeni, 2019).

2.2.1.3 Limitations of target costing

On the other hand, according to Kato, Boer and Chow (1995), if target costing is not used correctly, it may have adverse consequences for the organization. Regarding this, the main limitations of target costing are:

- **Excessively long development times** because of many changes to designs and costing, delaying the launch of the product on the market. The time spent searching for detailed cost information or quantifying certain factors can also have negative consequences such as loss of quality in products, due to the search for lower cost components (Yazdifar & Askarany, 2012). As a solution, Kato, Boer and Chow (1995) advise the organization to focus not only on costs, but also on quality and time.
- **Frustrated and demotivated employees** because even if they try their hardest, they may not achieve the targets. In order to avoid this demotivation, Kato, Boer and Chow (1995) advise management to define targets with the participation of the employees, so that they feel more involved and feel that they have an active voice. Another solution suggested by the author is to have a continuous improvement thinking rather than changing radically, since small continuous improvements are easier to achieve and, therefore, employees will feel more motivated and committed (Kato et al., 1995).
- **Organisational conflicts**. The development phase is one of the phases where most costs can be incurred and therefore saving therefore engineering managers often feel unfairly treated when they are encouraged to find savings in all operations compared to professionals in other areas such as marketing who are not under relatively great pressure, since they are considered as fixed costs and is difficult to control and therefore hard to define targets. For this reason, Kato, Boer and Chow (1995) as well as Ansari and Bell (1997), advise that Targets should be set for all costs including fixed costs such as marketing or distribution.

2.2.2 Kaizen costing

Kaizen costing as cost management procedure originated in Japanese companies after World War II. Kaizen costing which is called *Genkakaizen* in Japanese companies is an approach that is used at the production level as a cost reduction process and focuses on continuous improvement in all processes and customer satisfaction. It involves all employees of the company. Kaizen costing which was used in Japanese automobile companies were developed by Toyota Company as cost management techniques in 1960 (Ramezani & Razmeh, 2014). Monden and Lee (1993) expressed that Kaizen costing through continuous improvement or kaizen activities acts as target cost reduction and Kaizen costing activities keep the current level of production cost and begin to reduce production cost according to the company's plans.

Kaizen costing is a process of strategic management accounting that is a forward approach and outlook in search of competitive advantage for firms (Guilding et al., 2000). Point of strength in kaizen costing is its close relationship with the company's planning process and hence the company can evaluate its plans, progresses and long-term goals. Kaizen costing activities include incremental improvements, continuous reduction of production cost, and constant improvement in designing and developing products. In fact, Kaizen costing is continuous improvement and recovery by eliminating waste and reducing the cost (Kennedy & Widener, 2008) and it is related to the reduction of production cost considering the existing processes (Hansen et al., 2007). It contributes to ensure that the manufacturing of products meet the required quality, customer satisfaction, usability and affordable price to maintain the competitiveness of products (Ellram, 2006) and focuses on continuous cost reduction of products that are manufactured in the company (Cooper, 1995). Kaizen costing is a method including product design and improvement teams after the establishment and implementation of product and designing production process, and it focuses on the operational characteristics of production processes. The main focus of kaizen costing is on manufacturing process rather than products. In kaizen, cost reduction is a goal for each process. Thus, to achieve this goal, value analysis is used (Ramezani & Razmeh, 2014).

- **Value analysis**

  Value analysis is quite different from value engineering as both terms may sound the same and may raise a conflicting concept. While value engineering is applied to the product at the design stage and thus ensures prevention rather than elimination, value analysis is applied to the existing product with a view to improve its value and it is a remedial procedure. One of the main differences lies in time and phase of product life cycle at which the technique is applied (Celestine & Ramuolumeni, 2019). Value analysis is an organised approach to identify unnecessary costs associated with any product, material, part, component, system or service and, efficiently, eliminate them without impairing the quality functional reliability or its capacity to give service. According to Society of American Value Engineers (SAVE) “Value analysis is the systematic application of recognised techniques which identify the function of a product or services establish a monetary value for the function and provide the necessary function reliability at that lowest overall cost”.

Value-added analysis quantifies the level of waste existing in a given production process. Basically, the total elapsed time a part spends in various process activities on the shop floor is broken out between value and non-value-added time. Value-added time is the time spent in the process transforming materials into a product which adds more value to the product. Non-value time are activities such as inspection, rework, queues, moving material, and wait time spent in the transformation process that adds no benefit to the product. This is considered waste and an unwelcome cost by the firm. The ideal situation would be one where the value-added time of a product equals its lead-time. In this case there is no waste whatsoever in the process (Modarress et al., 2005).

Important aspects of kaizen are business and production elements improvement such as quality, cost, delivery etc. Quality improvements are in terms of features of production and product, cost improvements in terms of product cost, and delivery improvement in terms of time of the product distribution. Part of cost improvement is done by controlling and reducing unnecessary costs. For this purpose, kaizen costing techniques can be used for continuous improvement in the whole organization and kaizen costing is used for continuous reduction of production cost, thus being the basis of the kaizen ideology.

Japanese companies calculate kaizen profit or profit improvement based on the difference between target profit set by senior managers and estimated profit set by lower-level managers. Japanese car companies consider reduction of fixed and variable costs necessary in cost savings. They think that kaizen cost reduction can be achieved through a reduction in the variable cost of production departments and non-production departments, but the kaizen cost can also be considered for fixed costs. Cost reduction goal of kaizen is achieved by eliminating non-value-added activities and improving time management. Employees’ improvement suggestions are examined honestly and appropriate ideas are implemented for making improvements (Hilton et al., 2006).

The ratio of kaizen cost reduction goal is considered based on the expected profit or product margins, and it is generally 10% overall. After a few months of the start of a new product and after using target costing process, the cost is reduced through kaizen costing.

Cost targets in kaizen costing are proposed in the cost committee of kaizen and policies for implementing goals of kaizen (mainly non-monetary standards). In kaizen costing, the process through target costs is allocated to the various departments of the company. Factory employees participate in the daily activities of kaizen through proposing suggestions and contributing to the quality cycle. After introducing the product, customers demand for an increasing value of the product over time which can be achieved by increasing the value of products and/or reducing their cost. Kaizen costing process is an important interactional process between management and staff working group. Kaizen costing method uses target cost to reduce costs typically calculated according to the principles of standard cost. Kaizen costing system is an attempt to reduce the cost below the standard cost and achieve cost reduction targets (Ramezani & Razmeh, 2014).

Although most of the costs are fixed and defined at the development stage, when applied correctly by the company together with its suppliers, KC enables costs to be reduced, typically, by around 3%-5% per year, during the production phase.

It is this assumption that characterises the great advantage of using the kaizen costing tool because all these incremental gains/cost reductions at the end of the product life cycle become very significant because they occur annually and have repercussions on the overall costs of the company, reducing process costs and costs of other products (in production and to be produced in the future). In fact, the benefits of kaizen costing last over time (productivity gains will be incorporated in the new products) and impact on the processes, thus reducing indirect costs that affect other products in production (Leite, 2013).

2.2.2.1 Kaizen costing approaches

According to Cooper and Slagmulder (1999), kaizen costing can be applied at three different levels, depending on the objective and scope of the application, as shown below.

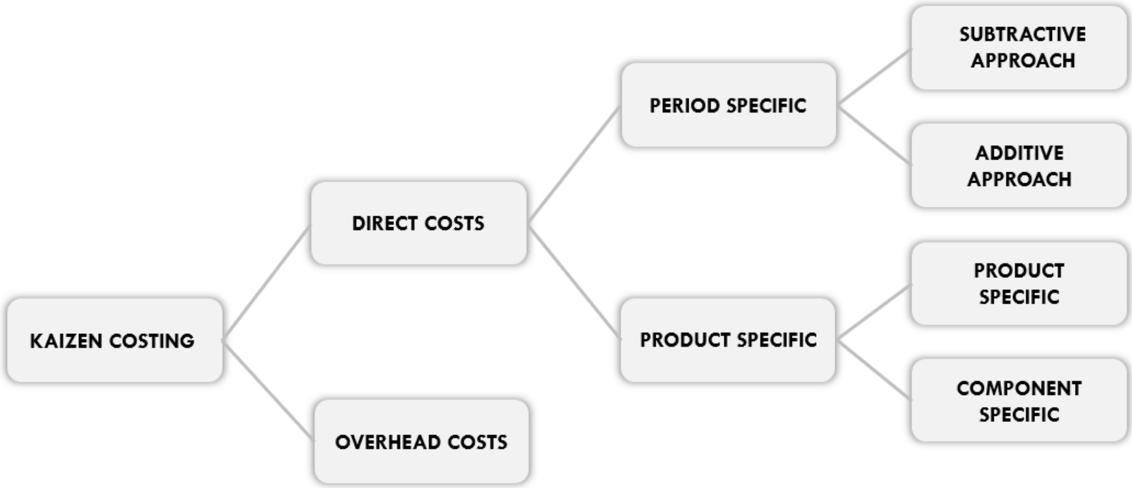

Figure 11 – Levels of kaizen costing

Period-specific kaizen costing

The period-specific kaizen costing intervention is focused on reducing the cost of production processes over a predetermined period while maintaining company's profitability levels. In this way, it seeks to find ways to achieve more efficient results through lower consumption of materials and labour and to generate lower overhead costs. As suggested by kaizen philosophy, the overall aim of cost reduction must also be considered, even in support activities, finding alternatives to incur the lowest possible consumption of resources. In the case of products with reduced life cycles, kaizen costing activities are already foreseen in the target costing process itself since its main objective is to ensure an adequate return on investment during the life cycle of new products. On the other hand, in the case of products with longer life cycles, there is an opportunity to invest capacity to reduce costs during their life cycle (Cooper & Slagmulder, 1999).

For products with shorter life cycles, the benefits of kaizen costing are minor for the specific product, but the effort will be capitalised in the future with other products, because kaizen initiatives will optimise production processes. According to Cooper and Slagmulder (1999), the gains from kaizen costing are cumulative, as 3% or 5% per year represent more than 12% or 15% cost reduction in five years. This accumulation of gains makes this period-specific kaizen costing approach so valuable. While a product may change every year, most production processes remain unchanged for several years. Consequently, savings occur over the entire life of the production processes, beyond the life of the actual products.

The period-specific kaizen costing starts by establishing cost reduction objectives thus, three approaches are distinguished to establish these objectives: the subtractive approach, the additive approach and the alternative approach (Santos, 2009).

Subtractive approach

In the subtractive approach, the company stipulates cost reduction targets, passing this information internally until it reaches each work group. The objectives can be different for each group and the cost reduction can be broken down into material consumption, labour and component costs. Regarding material cost reductions, they are normally defined globally by the company at the product level. On the other hand, regarding labour costs, the target is determined by each group taking also into consideration the performance of each production line. Finally, for cost reduction at component level, the cost reduction percentage for the period is fixed and the kaizen costing practice is extended to the entire supply chain.

Figure 12 shows the information flow, top-down and bottom-up, between the different levels. (Leite, 2013)

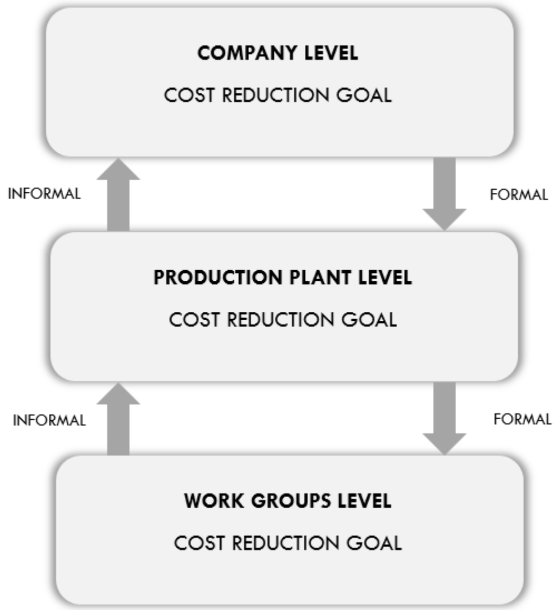

Figure 12 – Subtractive approach

Additive approach

In the additive approach, on the other hand, cost reduction opportunities are identified by the working groups and then summed up by the company level in order to check if the objectives will be met. In case that the opportunities proposed are not enough, the company will inform the working groups asking for more, repeating the cycle again. This process is the most effective when the working groups are highly motivated and aware of the importance of cost reduction (Figure 13) (Leite, 2013).

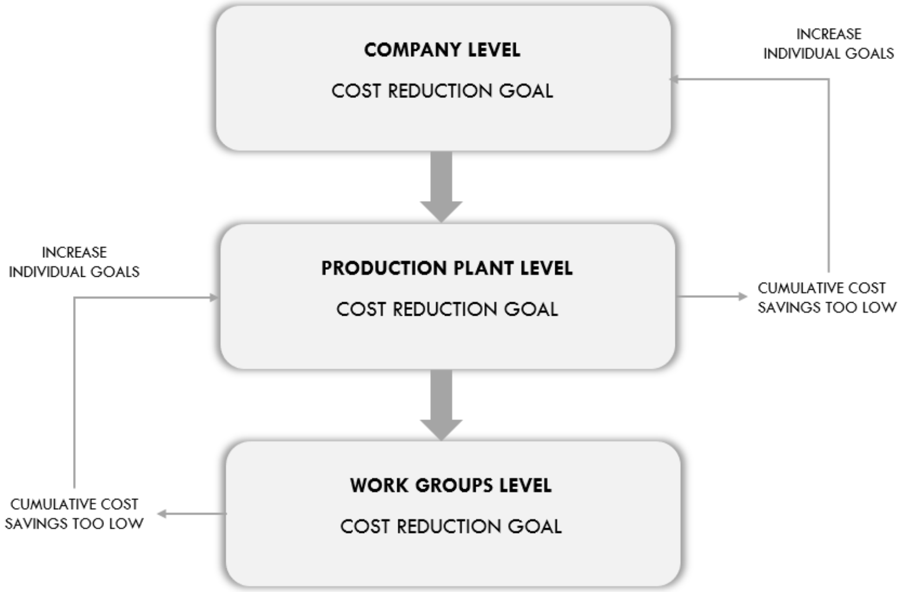

Figure 13 – Additive approach

Alternative approach

There is also a third and less common approach, known as alternative approach (Figure 14). In this case the cost reduction rate (KC factor) is defined equally for all work groups. Each organisation then works towards the same cost reduction rate. For the company it is simpler, but it will be less efficient. A rate limits the potential for cost reduction and workgroups tend to stick to the agreed rate.

Figure 14 – Alternative approach

Product-specific kaizen costing

The product-specific kaizen costing aims to ensure the profitability of a certain product and it is applied when a new product start being produced despite failing to meet the target costing objectives defined in the development phase. This situation may have occurred for strategic reasons, or it was considered with high certainty that costs (of materials components, technology, etc.) would decrease at the beginning of the production phase. However, this is considered an exception as it violates the cardinal rule of target costing. The cardinal rule states that in case the product does not reach the target cost in the development phase, then the production phase cannot take place. However, for strategic reasons, it may happen that the cancellation of the project is critical and harmful to the company and so, it chooses to move forward. There are some factors that may influence the decision that determines the progress towards the SOP (start of production) such as the use of new technologies or situations in which the company's image may be at stake. These are situations in which the company decides to move on to the production phase even though all the target costing indicators point to the unfeasibility of the project considering the required parameters (i.e., profitability, sales price, target cost).

Another situation in which the product-specific kaizen costing is used is in situations where the sales price stipulated during the development phase for a new product decline faster than expected. Some case studies point to the fact that excessively expensive products or components activate these kaizen costing programmes (Weil & Maher, 2005).

The product-specific kaizen costing can be distinguished into two levels of application: product-specific kaizen costing and component-specific kaizen costing.

The product-specific kaizen costing initiatives are oriented towards individual products and applied immediately after the target costing process. This process is triggered when the previously stipulated profit level for a particular product cannot be achieved. As mentioned above, the exact moment for the application of kaizen costing occurs at the mass production phase, when ideally the functionalities and the design of the product are already defined, meaning that any change cannot be perceived by the customer. Some factors that may trigger the need to activate product-specific kaizen costing programme are shown at Figure 15 (Cooper & Slagmulder, 1999).

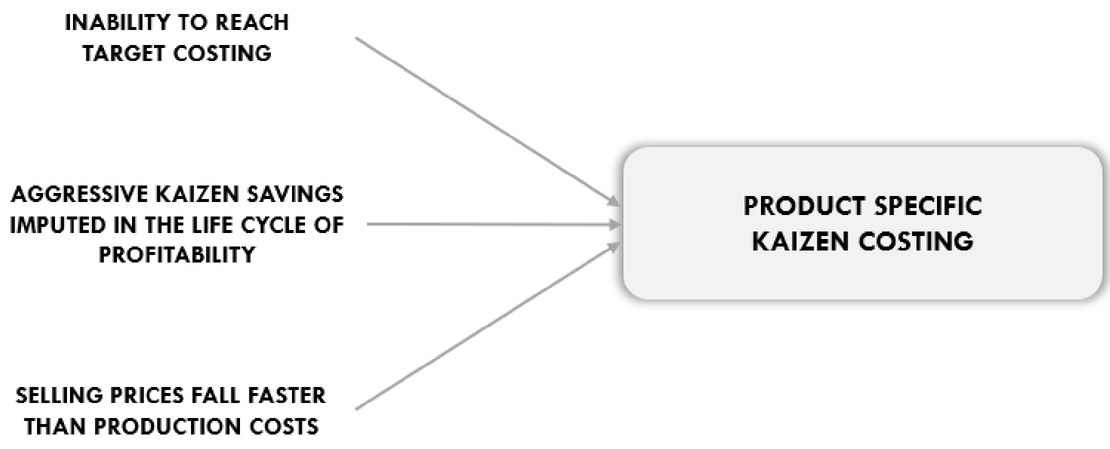

Figure 15 – Product specific kaizen costing

On the other hand, when component analysis often concludes that there are parts with excessive costs, component-specific kaizen costing is used. It is characteristic of the component-specific kaizen costing process that there are limitations on design changes. The moment of application is in the production phase and the designers are challenged to find solutions to achieve cost reduction objectives, but which do not affect the core design of the product. Figure 16 introduces some factors that can trigger the need to activate the component-specific kaizen costing programme (Cooper & Slagmulder, 1999).

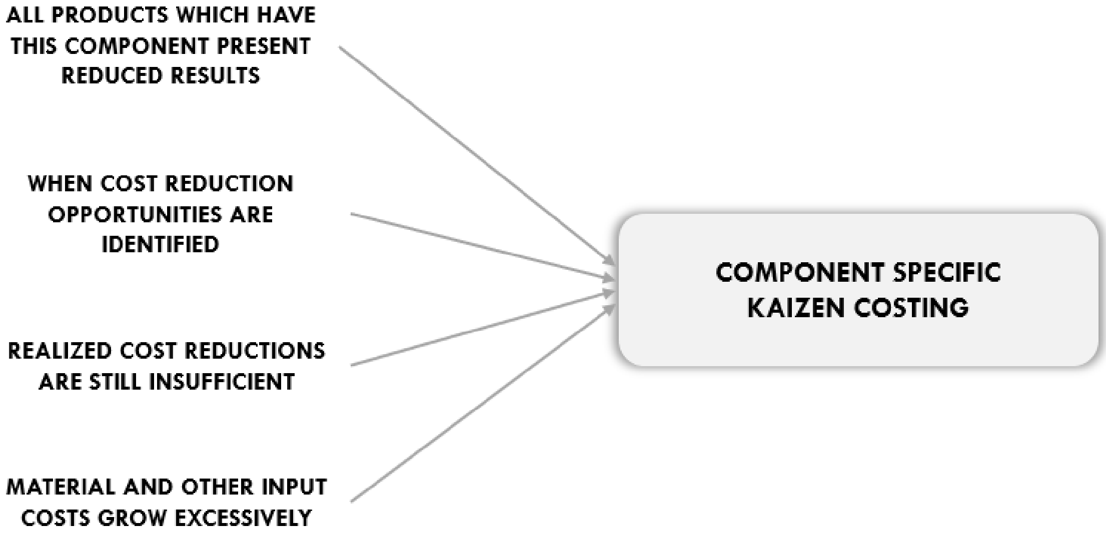

Figure 16 – Component specific kaizen costing

Overhead-specific kaizen costing

While the period-specific and the product-specific kaizen costing focus on direct costs, overhead-specific kaizen costing focus on indirect costs. This overhead-specific kaizen costing increase with the complexity and diversity of production and their reduction is based on the investigation of their root causes or cost drivers. The aim is generally to reduce the number of different components and to make profitable the common resources applied in different products. To achieve savings in overhead costs, kaizen costing initiatives have to be applied to several products. Significant overhead savings will only be achieved when the number of parts required by different products are reduced. However, these initiatives require going through several phases and over several years. The goal of reducing complexity is rarely achieved quickly. Once the objectives are met, a plan is established to maintain results and ensure that unnecessary complexity does not become a problem again. The overhead-specific kaizen costing concept overview is shown on the following figure.

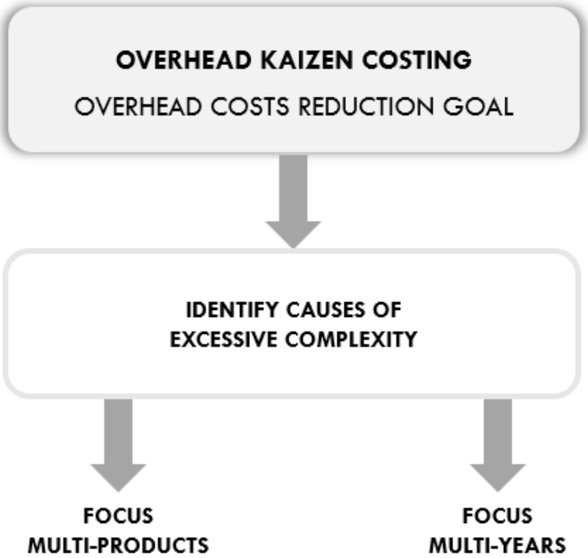

Figure 17 – Overhead kaizen costing

2.2.2.2 Benefits of kaizen costing

In addition to the benefits that have been mentioned above, using kaizen costing as a cost reduction technique can also be beneficial in the following ways (Prachi, 2019):

- **Customer satisfaction**: the kaizen costing is a customer-oriented technique which focusses on providing better service to the consumers.

- **Forming work teams**: every employee involved in the implementation of the kaizen practice needs to perform in a work team with a common aim of improvement.
- **Continuous improvement**: Kaizen costing is a technique which emphasizes on improvement of the product, process, project and the organization.
- **Creates better work environment**: It also promotes a positive work environment for the employees and the management. Like, sharing canteen and the dress code, is a part of work culture in many organizations.
- **Problem solving**: One of the crucial functions of kaizen costing is to solve the identified problem to achieve perfection in business operations.
- **Promotes cross-functional teams**: The teams so formed include employees with different skills and knowledge; thus, this technique encourages the formation of a cross-functional team.
- **Widely applicable**: Kaizen costing is universally applicable to all kinds of organizations, whether it is service industry or manufacturing industry.
- **Reduces wastage**: Due to better time management and material management in kaizen costing technique, the wastage of time and resources can be avoided.

2.2.2.3 Limitations of kaizen costing

On the other hand, according to Prachi (2019), if kaizen costing is not used correctly, it may have adverse consequences for the organization. Regarding this, the main limitations of kaizen costing are:

- **Permanent Change System**: the change implemented through kaizen costing is irreversible, and it requires a lot of efforts and cost in withdrawing such decisions. Also, the people may resist changing as they have to adopt new work while the current process already works for a long time. They will doubt change, which will provide better results or not. They still think that the existing work is good enough for them and the company, why need to change it.
- **Lack of Training**: kaizen costing requires a lot of expertise and training, and if not implemented strategically, it may even lead to adverse effects. It requires the company to provide regular training on both Kaizen philosophy and their working process. They have to think outside the box in order to find a new solution to the problem.

- **The burden on lower-level management**: it might become confusing and tedious for the bottom level management to adopt the change in process or product implemented through kaizen costing.

2.3 Business intelligence

The term Business Intelligence (BI) first came into use by an IBM researcher in 1958, when he published in an article the definition of BI as being the ability to capture the mutual relationships between the facts presented in order to guide strategies towards the ultimate goal (Luhn, 1958). BI systems are used more and more frequently by organizations, allowing managers to improve their decision-making process (Chaudhuri et al., 2011). The use of BI is seen as an asset for organizations, as it allows access to information at the right time, supporting decision makers in decision making.

The decision-making process is a fundamental aspect in the management of any organisation, being increasingly supported by structured analysis of available data. Considering that the success of an organisation is, in part, related to the decision-making process, it is natural that the instruments that provide an informed decision making are more and more appreciated.

Currently, companies have several information systems where data relating to the company's activities are recorded, forming databases with a large set of information. In turn, this data needs to be organized and managed, raising the growing interest of organizations in the use of BI tools capable of transforming the information present in databases into useful information (Cody et al., 2002).

In general, BI systems are data-driven decision support systems, providing a set of technologies, processes, storage, analysis and access to data that substantially improve the decision making of their users (Wixom & Watson, 2010).

BI systems are also defined by their ability to combine processes, culture policies and technologies for a good collection, manipulation, storage and analysis of the data that have been collected, both from internal sources and from sources external to the organization (Foley & Guilemette, 2010).

Elbashier, Collieret and Davern (2008), state that BI systems, in addition to enabling the improvement of the decision-making process of top management, they also enable the improvement of more operational processes such as production management or supply chain management.

As BI systems analysis tools, the most used are reports and dashboards. Reports are one of the most widely used tools, allowing data to be obtained from different sources, later providing well-structured data to stakeholders, through of dynamic tables, graphs, among other forms of representation (Janus & Misner, 2011). In turn, dashboards are tools that condense various measures and indicators in a single view, using various types of graphics, Key Performance Indicators (KPI), relevant statistics, among several other possibilities. The dashboards have the ability to provide all the necessary information in an intuitive manner, and with the ability to create alerts for eventual critical situations.

2.3.1 Business Intelligence advantages

The benefits of business intelligence tools are plentiful and the most advantageous of them are (Pavan, 2021):

Figure 18 – Business intelligence advantages

1. **Relevant and accurate reporting:** using different kinds of data sources, employees can customize their reports and monitor KPIs. Real-time generated reports offer the most pertinent data, which help companies make faster and better decisions. Data from sales, finance, or operations are used to create easily accessible reports, have great visualizations with the help of charts, graphs, tables, etc. These reports offer faster insights, access, accuracy, and relevancy.
2. **Key insights:** BI reporting tools assist in monitoring. To get the complete insight on revenue, losses, gains, the productivity of the employees, performances of the employees. It provides valuable information about the positives and the negatives insights. With these tools, companies can easily track the metrics and be current with

what's happening and what's to come by setting up alerts, getting real-time information on the KPIs, and alerting any pitfalls that otherwise could have gone unnoticed.

3. **Stay ahead in the game:** companies of all sizes have vast amounts of data. Moreover, managing and using data for business decisions provides a competitive edge. BI offers incredible benefits with the help of this data in terms of forecasting, budgeting, planning, and staying on top of things via analysis. Competitive analysis helps companies to know the competition and the performance of their competitors as well. This, in turn, leads to finding out how to differentiate one's products from others. It goes the same for services as well.
4. **Quality and accurate data:** The success of any kind within an enterprise is data dependent. Quality of data defines the quality of the company and its success. Any inaccuracies or flaws in the data can turn businesses upside down. BI tools help businesses in cleaning up data, creating data of high quality, collecting, updating, and analysing data to gain the most relevant insight on what is going on within the company.
5. **Improved customer satisfaction:** business intelligence software mainly helps companies to not just learn about their employees but their customers too. These BI tools help to identify what is lacking with your services or products and enhance customer satisfaction by making necessary changes. Real-time data on the customer's feedback help in bringing corrective changes and deliver excellent customer service and satisfaction.
6. **Improve growth patterns:** BI assists companies in gaining a competitive edge by helping them find new opportunities and build smarter strategies. With the help of all the data, you can identify market trends and help improve profit margins for the company. New sales trends can be identified by leveraging data from the internal and external markets, analysing the data. The market conditions can help spot any business issues that can otherwise go unnoticed.
7. **Efficiency and accuracy:** BI tools offer a single source of information; it helps the employees or the executive hierarchy to spend more time on productivity and less time on managing data. This way, employees can focus on producing reports and timely deliverables in real-time. This accurate information leads to better decision making and helps companies achieve long and short-term goals.
8. **Faster decision making:** BI is essential in gaining a competitive edge for companies to make faster and accurate decisions by leveraging the existing data, at the right time, and improve decision making.

9. **Greater operational efficiency and increased revenue:** BI tools offer business data, which makes the leaders and employees of a company think about the decisions made, processes implemented, and strategies executed. Getting a 360-degree view on all the dimensions to help companies identify issues and improve operations, increased sales, and in turn, increase revenue.
10. **Bigger profits:** Most businesses find profit margins as a big concern. BI tools can analyse from the enormous volumes of data any discrepancies, inefficiencies, errors, etc. It helps expand profit margins, and the sales teams get better insights for future sales and analyse where to spend the budgets in the future.

2.3.2 Business Intelligence disadvantages

Despite its many benefits, BI comes with its fair share of disadvantages. Here are five common challenges with BI (Danziger, 2020):

1. **Data breaches:** one of the most pressing concerns with any data analysis system is the risk of leaks. If you use BI applications to handle sensitive information, an error in the process could expose it, harming your business, customers or employees. More than 30% of surveyed businesses cited security issues as the biggest challenge facing BI.
2. **High prices:** business intelligence software can be expensive. While the potential for a high Return on Investments (ROI) can justify this, the initial price can be a barrier to smaller companies. the costs of the hardware and IT staff needed to implement the software effectively should also be considered.
3. **Difficulty analysing different data sources:** the more encompassing your BI, the more data sources you will use. A variety of different sources can be beneficial in giving you well-rounded analytics, but systems may have trouble working across varied platforms.
4. **Poor data quality:** in this digital age, you have more information at your disposal than ever, but this can prove to be problematic. A surplus of data can mean that a lot of what your BI tools analyse is irrelevant or unhelpful, muddying results and slowing down processes.
5. **Resistance to adoption:** not all disadvantages of BI deal with the software itself. One of the most substantial obstacles facing BI is employees or departments not wanting to integrate it into their operations. If the company does not adopt these systems across all areas, they will not be as effective.

3. RESEARCH METHODOLOGY

The first step in the development of a research project consists of defining the study to elaborate and its purpose. Once this phase is completed, it is essential to reflect on the methodology to apply throughout the investigation.

The methodology to be used defines the guideline of the entire investigation, as it influences the selection of methods and techniques that make it possible to achieve the previously defined objectives. According to Bogdan & Biklen (2003) the methodology provides the scope of the research purposes; thus, its selection should be made in a considered way, requiring a strong reflection/study from the researcher.

Regarding the nature of research, there are two main paradigms - the qualitative paradigm and the quantitative paradigm. One way of differentiating quantitative research from qualitative research is to distinguish between numeric data (numbers) and non-numeric data (words, images, video clips and other similar material). In this way, ‘quantitative’ is often used as a synonym for any data collection technique (such as a questionnaire) or data analysis procedure (such as graphs or statistics) that generates or uses numerical data. In contrast, ‘qualitative’ is often used as a synonym for any data collection technique (such as an interview) or data analysis procedure (such as categorising data) that generates or uses non-numerical data (Saunders et al., 2019). This project combines quantitative elements, such as costs, obtained by cost analysis, and key performance indicators, and qualitative elements, such as processes description, obtained through observation, and analysis of Bosch’s directives.

Then, for the elaboration of this dissertation, it was decided that the research methodology to be used, and that best suited, would be the methodology of “Action Research” as the investigator will also be involved, together with the organization's employees, in the implementation of solutions (Saunders et al., 2019).

3.1 Action research methodology

Action Research is a methodology that includes action (change) and research (investigation) simultaneously, based on a cyclical and spiral process that aims to produce theoretical reflections that contribute to solving problems in real situations.

Zuber-Skerritt (1992) emphasizes that this methodology is characterized by being collaborative, meaning that all stakeholders are research executors as well as agents of change.

The characteristics most commonly attributed to action research from the point of view of several authors are:

- Participatory, as there is sharing of ideas and collaboration between the various participants for changing practices.
- Practice, since it is not limited to the theoretical field, intervening in the resolution of real problems.
- Cyclic, as the investigation takes place through a process that includes steps systematic and sometimes interactive. There is a continuous link between theory and practice.

In this project, the preparation of the respective improvement proposals regarding some procedures, as well as the definition of performance indicators and the consequent elaboration of the dashboard and the design of the process, were always carried out with the support of the respective employees of the organization, as they, as experts in the company's reality, will be essential for validation. In addition, the respective project is carried out in a business context, presenting, therefore a very high practical component.

3.2 Research project steps

According to Susman and Evered (1978), this research methodology is also known by the expression “learning by doing” and is organized in five phases (Figure 19):

A. Diagnosis

In this phase, the process under study was critically analysed, together with employees, in order to deepen the knowledge about the current state of the section, as well as all interconnected sections. This knowledge was essential for the subsequent definition of performance indicators to be included in each process and consequent construction of the dashboard and the value stream design of the RPP process.

The data required for the diagnosis was mainly derived from primary sources, namely, internal records/documents of the organisation.

B. Action planning

After the diagnosis phase, it is essential that a literature review is carried out in order to find different possible approaches to solve the challenges identified. These actions are analysed together with the organisation's employees, in order to check their feasibility. The literature review essentially addressed the following topics: project management, cost management and business intelligence.

C. Action taking

Once the plan that contemplates the approaches to solving the problems has been defined, the implementation and monitoring of the respective actions is carried out at this phase. Thus, it was initially planned to design the RPP process, through VSDiA, seeking to optimise it by reducing waste. Then, in a second stage, the aim was to design and build a dashboard in power BI that includes the performance indicators regarding RPP, allowing real-time monitoring.

D. Evaluation of results

After the measures have been implemented, in order to confirm whether the implemented improvements had positive results, the results are analysed and evaluated, comparing them to the situation described in the first phase, the Diagnostic phases, based on relevant indicators for the evaluation. Besides the comparison of performance indicators, two surveys were also carried out to validate the changes made. These surveys were answered by the main stakeholders of the process.

E. Specification of learning

Finally, in this phase the main conclusions were analysed, listing possible points that have remained open, which may represent opportunities for future improvements.

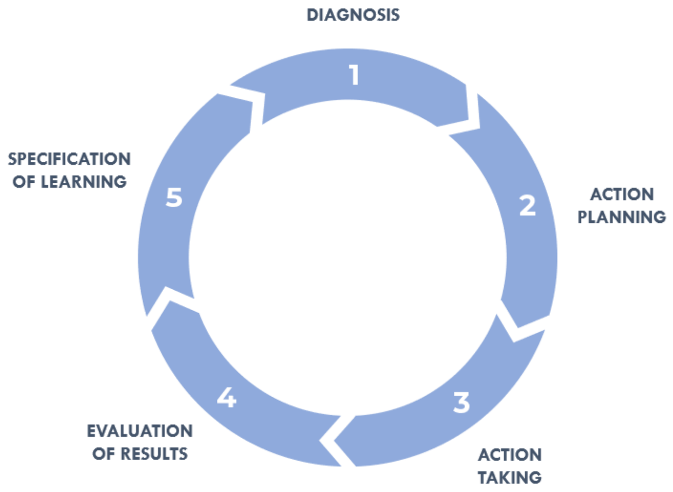

Figure 19 – Phases of Action Research methodology

4. Case Study

The present study aimed to act in two main fields, one related to the improvement of existing procedures in the organisation and the other regarding the development of new tools providing the company with more efficient control mechanisms.

This chapter contains, in the first section, a brief presentation of the company where the project was carried out. Then, the current state of the PPR methodology is described in the second section. Finally, in the last section, the implemented improvements are presented and described.

4.1 Company presentation

The aim of this section is to describe the company, Bosch, where the research was developed. The company is presented both globally and nationally, discriminating its main business areas. Finally, to contextualise the relevance of the work developed, in this chapter a special attention is also given to the department MFE1, in which the study was developed.

4.1.1 Bosch group

The Bosch group, world leader in the supply of technology and services, has built its history on a strategy that seeks, in a sustained way, long-term economic success. The name of the company comes from its founder Robert Bosch (1861-1942) who, at only 25 years old, set up the company as a "Workshop for precision mechanics and electrical engineering" in Stuttgart (Germany) (Bosch internal communication, 2021).

Figure 20 – Bosch logo

The Bosch group, headquartered in Schillerhöhe, on the periphery of Stuttgart, employs roughly 395,000 associates worldwide (as of December 31, 2020) and contributed 71.5 billion to sales in 2020. The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiary and regional companies in more than 60 countries. Including sales and service partners, Bosch's global manufacturing, engineering, and sales network covers nearly every country in the world. The Bosch Group has been carbon neutral since the first quarter of 2020 and the basis for the company's future growth is its innovative strength. At 129 locations across the globe, Bosch employs some 73.000 associates in research and development (Figure 21) (Bosch internal communication, 2021).

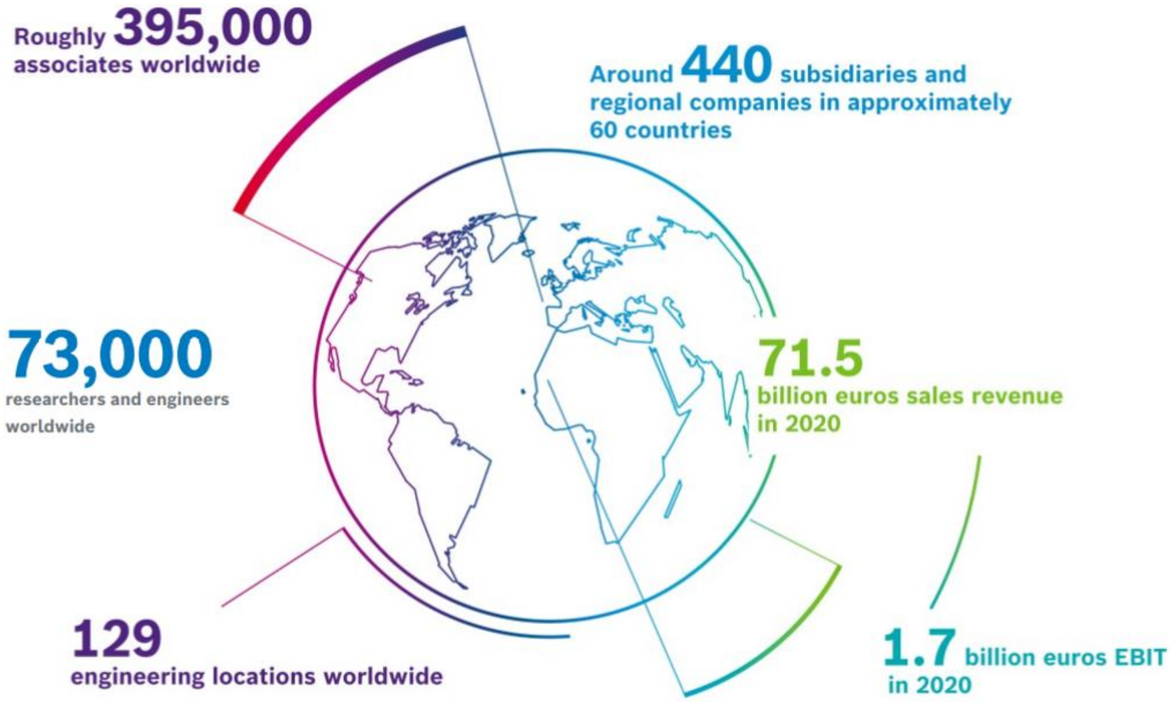

Figure 21 – Bosch group numbers
(Bosch internal communication, 2021)

The Bosch business structure is divided into four main groups: Mobility Solutions, Industrial Technology, Consumer Goods and Energy and Building Technology. Each group is divided into several business units as illustrated in Figure 22.

Figure 22 – Bosch business sectors and business units

(Bosch internal communication, 2021)

Regarding the sales on 2020, the mobility solutions sector presents a greater prominence, reaching about 59% of total sales, followed by the area of consumer goods representing 26%. On the other hand, with less impact, the Industrial Technology sector and the Energy and Building Technology sector represent 7% and 8%, respectively (Figure 23) (Bosch internal communication, 2021).

Figure 23 – Sales per business sector

(Bosch internal communication, 2021)

4.1.2 Bosch Portugal

Bosch made its debut in Portuguese territory in 1911 and is currently one of the most recognized companies in Portugal, being represented in four locations, where it develops and manufactures a wide range of products. Guided by an innovative vision and focused on technological innovation, Bosch Thermotecnhology, in Aveiro, Bosch Car Multimedia S.A, in Braga, and

Bosch Security Systems, in Ovar, develop and produce hot water solutions; car sensors and multimedia; and security and communication systems, respectively. The Group's headquarters in the country is in Lisbon, where activities in the fields of marketing, accounting, communication, sales and human resources are carried out. In addition, the company has a subsidiary, BSH Appliance, in Lisbon.
With around 6,360 employees (as of 2019), Bosch is one of Portugal's largest industrial employers and generated €1.8MM in sales in 2019 (Figure 24) (Bosch internal communication, 2021).

Figure 24 – Bosch Portugal
(Bosch internal communication, 2021)

4.1.3 Bosch Car Multimedia Portugal, S.A – Braga

The history of this unit in Braga began in 1990 with the opening of the Blaupunkt factory. At that time, the unit was dedicated to the production of car radios and aftermarket accessories, assuming a position of relevance for the region and for the country.
With the evolution of the automotive market demands, in 2009 the brand was sold, and a reorganization of this unit started, which would become Bosch Car Multimedia Portugal, S.A., dedicated to the development and production of infotainment systems, instrumentation and security sensors for the automotive industry (Figure 25) (Bosch internal communication, 2021).

Figure 25 – Portfolio Bosch Car Multimedia Portugal, S.A – Braga

(Bosch internal communication, 2021)

As a result of the demand for increasingly sophisticated technologies, in 2012, Bosch signed the largest innovation partnership in Portugal with the University of Minho.

Currently, the unit in Braga belongs to the Automotive Electronics division. In this same unit is one of Bosch's centres for the development of solutions for connected and autonomous mobility, which has more than 350 engineers. The company exceeds, in 2019, the count of 3500 employees in Braga, standing out for its qualified workforce.

The organizational structure of Bosch Car Multimedia Braga is divided into 2 main areas: commercial and technical (Figure 26) (Bosch internal communication, 2021).

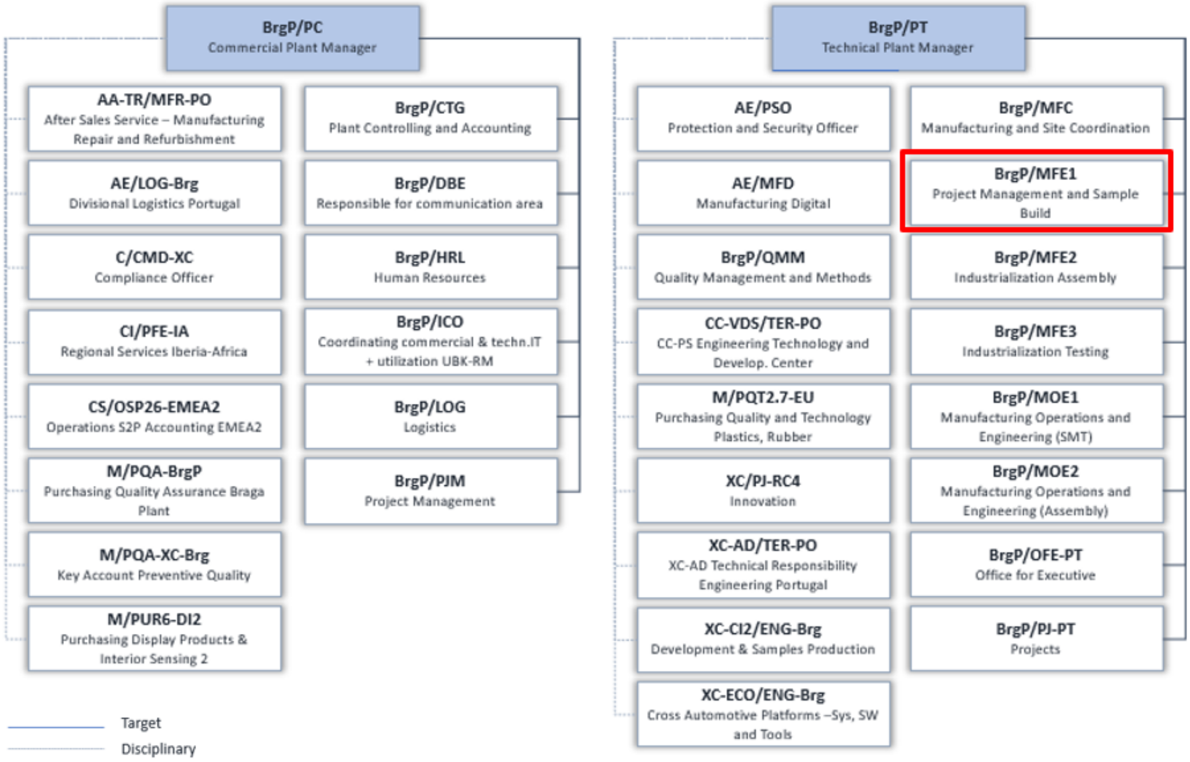

Figure 26 – Bosch organizational structure

(Bosch internal communication, 2021)

The commercial area consists of the departments that do not make a direct contribution to the product, based on accessory functions of equal value to the process. This includes, for example, the Logistics, Human Resources and Purchasing departments, among others. On the other hand, the departments included in the technical area are those which perform functions which directly affect the product. This is the case of the Engineering, Quality and Production departments, among others. The department where the dissertation will be carried out, MFE1 (Manufacturing Engineering), is inserted in this area and is responsible for Project Management and Sample Build (Bosch internal communication, 2021).

4.2 Current Situation

In order to understand the RPP methodology, a description of the current status is presented in this section. For confidentiality reasons and industrial property rights all information regarding the ratio project has been hidden or changed. However, the conclusions that have been reached have not been modified.

Ratio Project Planning (RPP) is a process that describes all the activities necessary to make a product in the production phase more profitable by decreasing costs. The following figure highlights the moment of intervention of the RPP methodology in the life cycle of a product. Passing the phase of the development of a product, the work of cost management in the production phase is supported by the RPP methodology.

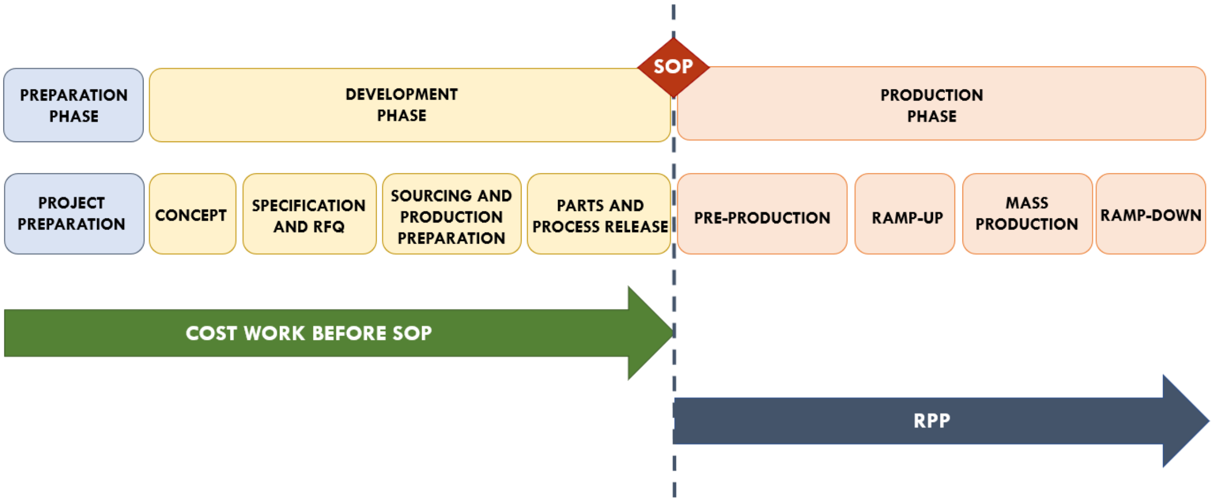

Figure 27 – RPP intervention in the life cycle of a product

The objective of the RPP is to promote, coordinate and enable product-related actions that have a cost-saving effect on the business plan. The costs with a focus on the scope of the RPP (Figure 28) are related with PPC (Product Planned Costs) which includes costs with inputs (i.e., Materials) and costs that generate Value added (e.g., direct labour, indirect costs). Cost regarding SG&A (Selling, General and administrative costs) do not belong to the scope of RPP.

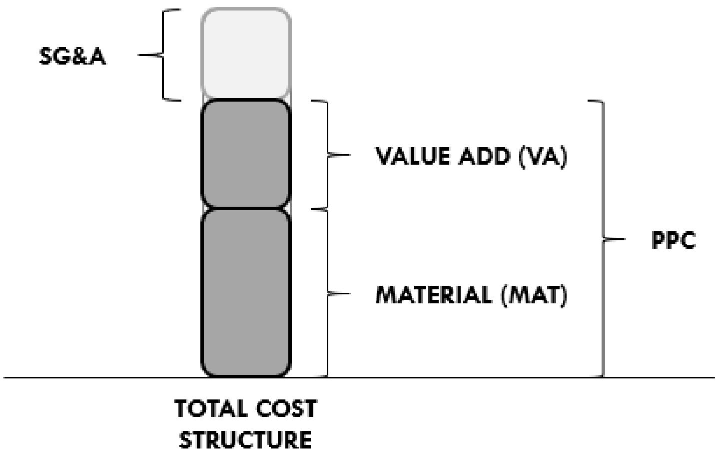

Figure 28 – Total cost structure

The business plan assumes the existence of RPP projects, so each RPP must be shared and reported to management on a monthly basis, so that the management has an aggregated view

of all the company's RPPs. The lists of RPP ideas are in excel files, called Open Point Lists (OPLs). There is one OPL for each variant in the focus for product cost optimization.
The RPP arise from needs identified by the client or by the company itself, and then become an opportunity to reduce costs and increase profit. Once the viability of the proposed changes is proven, the collaboration of all departments is again required for their implementation. In general, RPP projects contain the following topics (Figure 29):

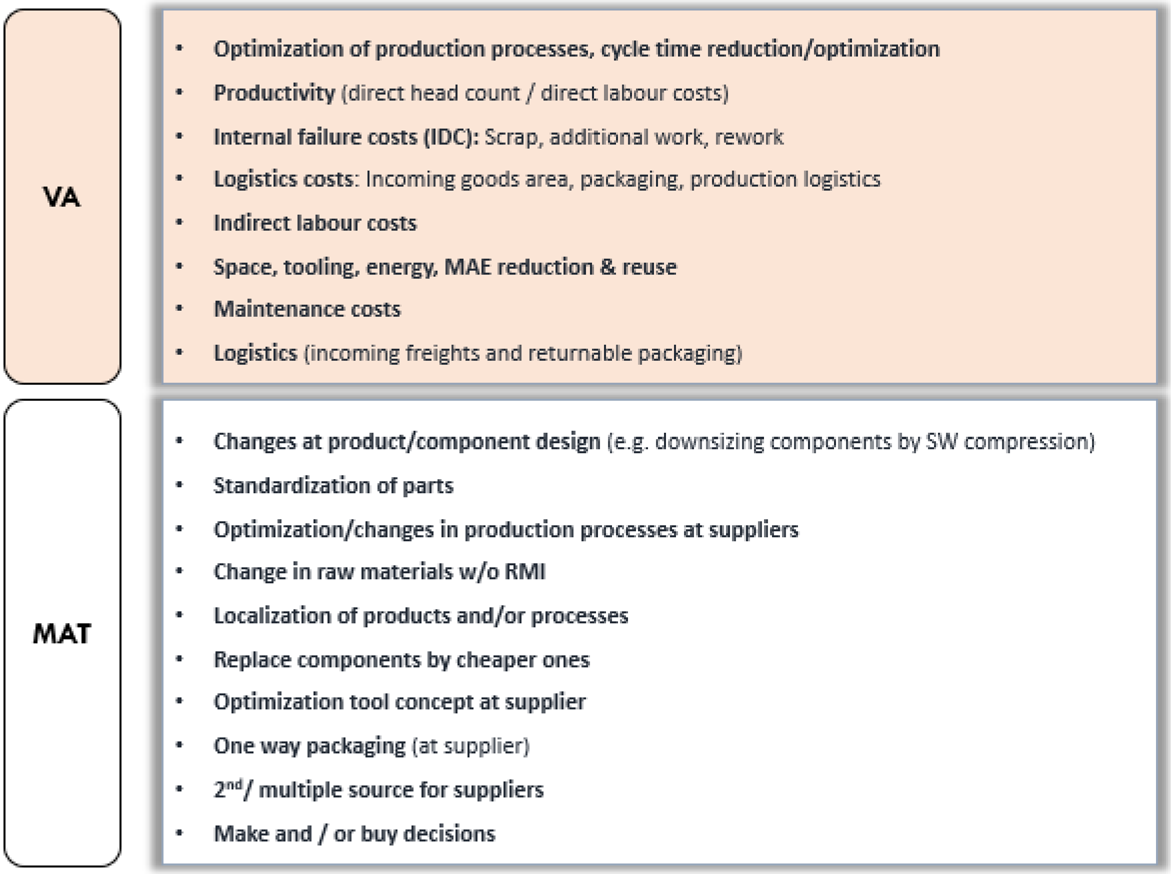

Figure 29 – RPP topics

On the other hand, it is important to mention that there are changes that do not result in RPP such as (Figure 30):

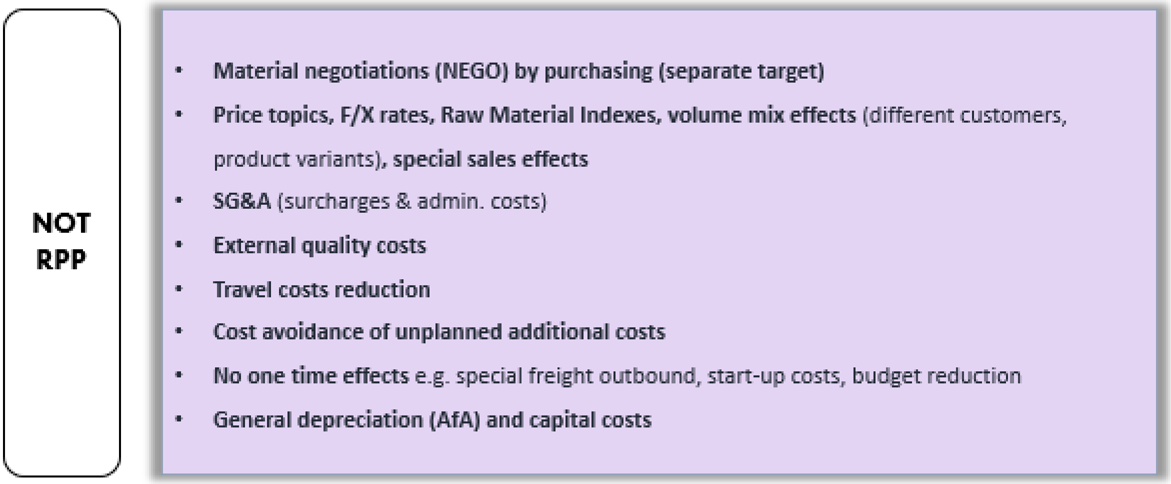

Figure 30 – Not RPP topics

Also, in order to understand the concepts used in RPP, a brief description of the most used expressions is presented below:

- **Measure:** in general, an RPP measure is a real and specific technical <u>idea</u> (material, design, value add) with the goal of optimize the product costs.

- **Hardness Grade** (HG): the hardness grade, in RPP, corresponds to the maturity level of the idea. An RPP measure can be in the following different status (Table 1):

Table 1 – Hardness Grade

Hardness Grade (HG)	Description
HG 1	Idea
HG 2	Planning phase
HG 3	Implementation phase
HG 4	Introduced in BOM / production process approved
HG 5	Cost effective (series production)
HG 7	Rejected due to effort greater than benefit, but is an idea for other projects
HG 9	Rejected due to technical feasibility

- **Business Unit (BU):** A business unit is a segment of a company with strategic objectives separate from the parent company but enhances the overall performance of the enterprise. The two examples we can find in this guide are the XC-CI1 and XC-CI2 business units.

- **Project:** in this dashboard, the word project concerns to customers. Examples of projects presented: Audi, BMW, Ford, JLR NGI, Porsche, PSA, RN A-IVI and Volvo.

- **Product family:** on the other hand, product family designation concerns to variants. Each project can have more than one product family. For example, the Volvo project has the Volvo i-Cup and the Volvo SPA Dim product families, and the Audi project has the Audi FPK C-BEV, the Audi FPK Gen.2, the Audi FPK Gen.2+ A3Nf, the Audi FPK Gen.2+ B9PA, the Audi FPK Gen.2+ RO and the Audi FPK Gen.1 product families.

- **Value added (VA):** value add is an RPP measure category, regarding mainly the production topics (i.e., reduction in cycle time (VT, TeB minutes), MAE, EWAK, IDC (Internal defects costs), headcount, floor space reduction, transportation inbound (supplier to Plant), packaging design…).

- **Material (MAT):** Every "technical" measure, that changes the product (i.e., BOM, change material or part (fit, form, function, testing…), tooling at supplier, packaging, supplier development or second source, transportation).

- **Year:** the year concept is regarding the year presented in the SOP (start of production) date.

- **Contribution year:** as the RPP measures only contributes, in terms of reporting, 12 months, meaning that each measure will have 1 or, in maximum, 2 contribution years.

  Example: a measure that was implemented in 07/2021 will have impact until the end of the project lifetime, however, in terms of RPP, it will contribute just 6 months in 2021 and 6 months in 2022, so the contribution years of that measure are 2021 and 2022 (Figure 31).

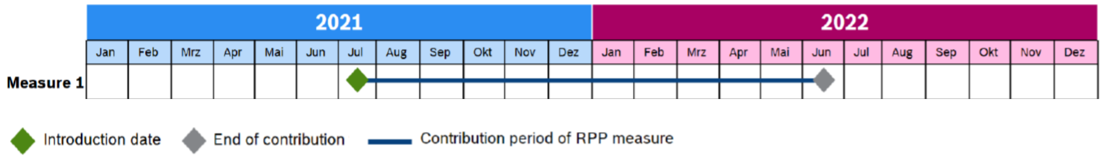

Figure 31 – RPP contribution

At Bosch in Braga, there are currently no departments and employees dedicated exclusively to carrying out RPP projects. This situation may restrict the available capacity of each member for activities associated with RPP projects.

The realisation of an RPP project goes through several phases with a medium-long lead time, as it can often be necessary, for example, to involve several departments, use several tools, go through negotiation phases and control several activities. These activities require constant exchange of information and consume large levels of capacity for strict planned deadlines to be met. Figure 32 illustrates an overview of all phases of the RPP methodology from the moment of its creation, from an idea to its implementation.

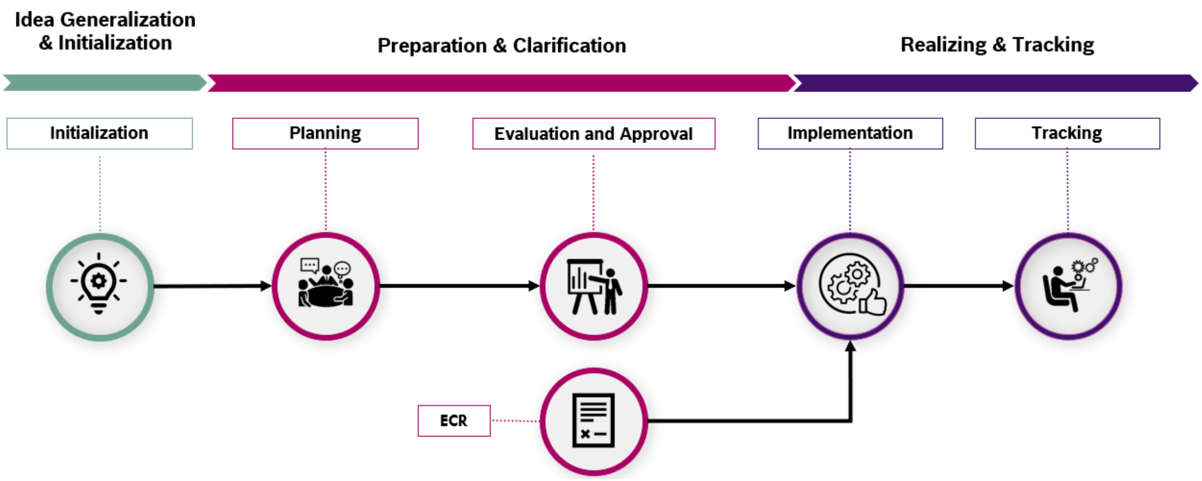

Figure 32 – RPP process

Idea Generalization and Initialization

Each department should be aware to check the chances of ratio in their activities. For that, each employee should consider that the emergence of an activity can be an opportunity to become a ratio project. On the other hand, within the scope of RPP, workshops are organised, mainly for high-runner projects or projects with large investments or projects with low performances, in order to generate several ideas with the purpose of optimising the cost of the product. In these workshops, several stakeholders participate, such as product developers, assembly managers, testing managers, packaging managers, quality managers and the RPP coordinator. Previously, the RPP coordinator collects important information for the generation and discussion of potential ideas such as line balancing charts, explosive view of components, product cost breakdown, production line layout, process flow, top scrap rate, internal rejection rate report and technical specifications, namely hardware and software. During the workshops, with the support of the information previously collected and presented to the team, line walks, assembly process analysis, material analysis and specification analysis are performed with the purpose of generating ideas to reduce product cost. These ideas are recorded in a Workshop OPL (Open point list) and, after some analysis, if the team's decision is to go ahead with the idea, it is migrated to the respective OPL, where the tracking of ideas takes place (Figure 33).

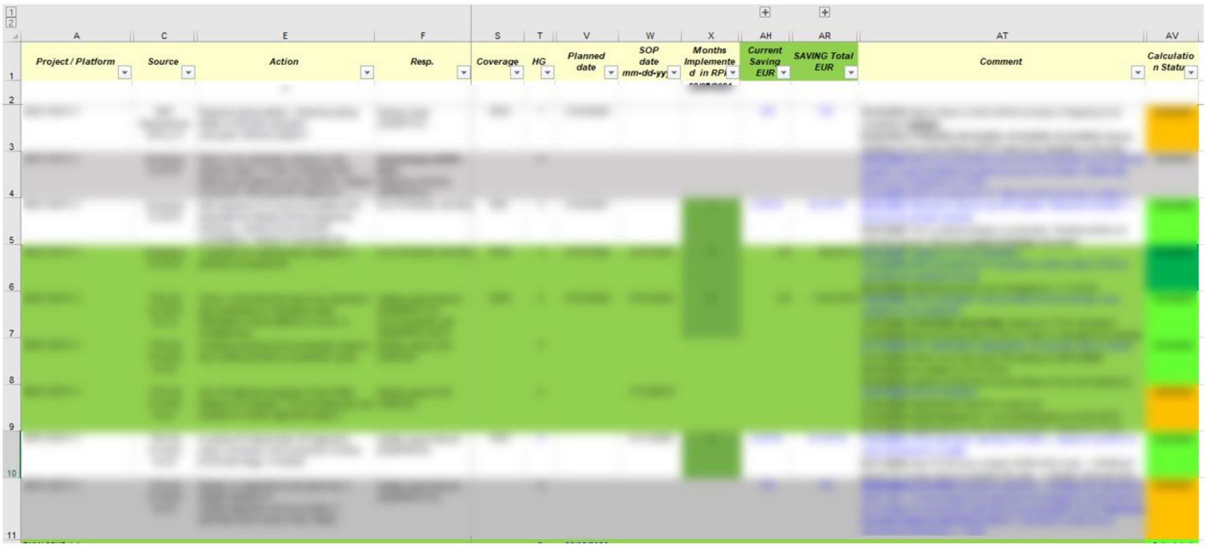

Figure 33 – Open point list (OPL)

Preparation and Clarification

Once the list has been analysed and validated by the project team, it is necessary to coordinate the activities required for the assessment and respective approval.

To evaluate an RRP project, the project coordinator organises and coordinates a team which considers in its assessment: the potential improvements, the required efforts and planned capacity, expected implementation date, customer receptiveness and risks of the project.

All activities require inter-departmental cooperation, capacity planning, good communication and the respective follow-up to elaborate the project execution planning.

With this data, an ECR (Engineering Change Request) is created if the team considers it necessary. Although the ECR starts at this stage, it will run until the measure is implemented or abandoned. The ECR process involves significant expenditure in human and financial resources. Engineering changes are only permitted if they are proven to improve customer satisfaction, competitiveness and/or product quality. They can be triggered by any Bosch collaborator or by an external contribution. This process also goes through different phases until its conclusion. Figure 34 describes the phases of an ECR process.

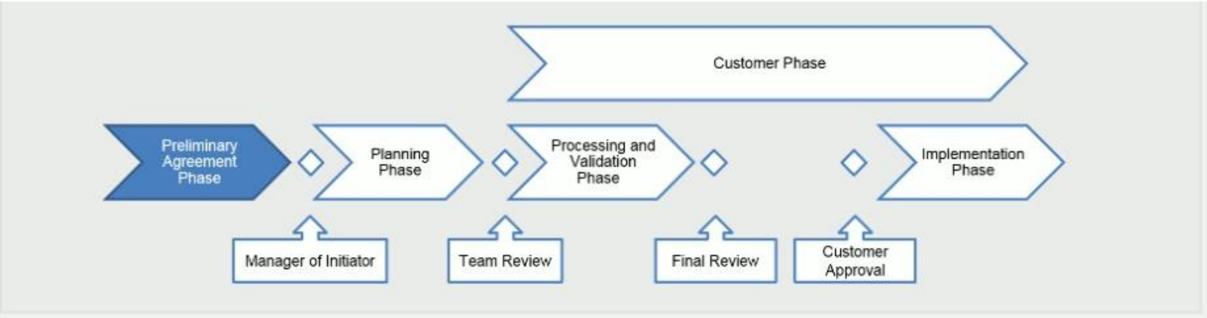

Figure 34 – ECR process

Initially the input that can trigger ECR activities is analysed and if its benefit is evident, it is necessary to nominate a team to plan the activities that will enable the implementation of this requirement. At the end of the planning, the viability of the implementation is concluded, considering budget, conclusion date, client involvement, priority and/or continuity. After the activities are approved and there are positive results, it is necessary to involve the sales department to present the results to the customer. The customer's decision (internal or external) will have to be documented.

Once the company and the customer agree with the implementation plan, the plant move on to the implementation phase.

Realizing and Tracking

The final phase of a RPP project is its implementation and monitoring. It is necessary to initiate the process of implementing the changes involved in the RPP project and to coordinate the whole process with the departments involved. It is necessary to certify and pursue the effectiveness of the planned results. The RPP coordinator is responsible for this follow-up, collecting all the necessary information and, if necessary, highlighting identified blockers or constrains.

RPP Monthly report

The current status of the RPP measures is presented to management every month, reporting on various indicators with the purpose of presenting the evolution of the product cost optimisation measures and respective contribution and also to request support on some points, if necessary. Some indicators and analysis shown in the reports are presented below:

- Total ideas by Hardness Grade

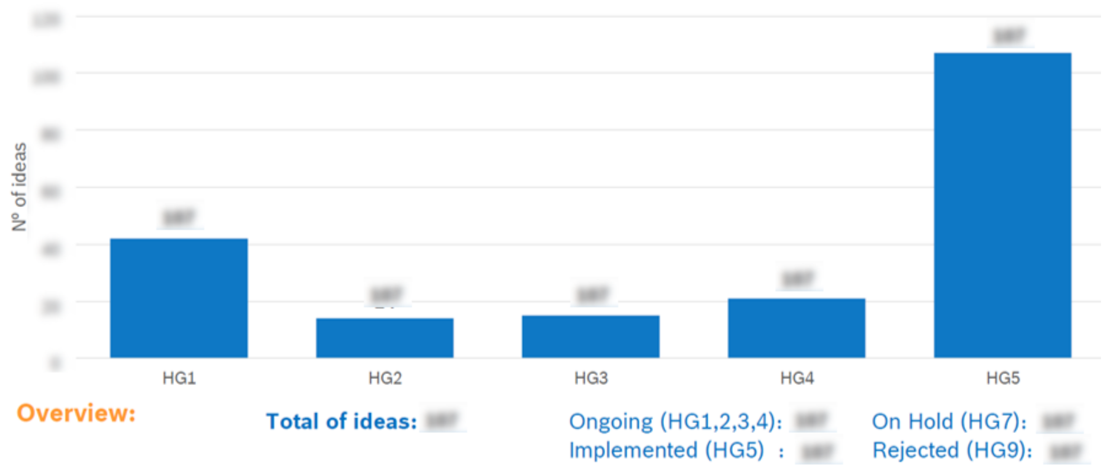

Figure 35 – Total ideas by Hardness Grade

- Overall ideas per Project and per HG

Project	Total Ideas	HG1	HG2	HG3	HG4	HG5	HG7	HG9	Nrº of ideas with Savings
2W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RN A-IVI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AUDI ALL GENs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BMW 35UP 4.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FORD C-HuD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JLR NGI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Porsche 992	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PSA RCC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
VOLVO SPA DIM + iCUP EU	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 36 – Overall ideas per Project and per HG

- Overall ideas per Project w/Saving (€)

Project	Nº of ideas with Savings	RPP Saving 2021 (HG5) EUR	Total Pot. Saving OLT (HG1-HG4) EUR	Total Pot. Saving OLT (HG5) EUR
2W	[illegible]	[illegible]	[illegible]	[illegible]
R/N A-IVI	[illegible]	[illegible]	[illegible]	[illegible]
AUDI ALL GENs	[illegible]	[illegible]	[illegible]	[illegible]
BMW 35UP 4.1	[illegible]	[illegible]	[illegible]	[illegible]
FORD C-HuD	[illegible]	[illegible]	[illegible]	[illegible]
JLR NGI	[illegible]	[illegible]	[illegible]	[illegible]
Porsche 992	[illegible]	[illegible]	[illegible]	[illegible]
PSA RCC	[illegible]	[illegible]	[illegible]	[illegible]
VOLVO SPA DIM + iCUP EU	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]

Figure 37 – Overall ideas per Project w/Saving

- RPP Potential Savings across the year

Figure 38 – RPP Potential Savings across the year

- Top 5 of Implemented Ideas (HG5) (all and for each project)

Estimated
Calculated

Project	Idea	Int. date	Pot. Saving EUR/Unit	Calculation Status	RPP Saving 2020 EUR	Total Pot. Saving OLT
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 39 – Top 5 of Implemented Ideas (HG5)

- <u>Top 5 of Ongoing Ideas (HG1-4)</u>

Estimated
Calculated

Project	Idea	Planned Int. date	HG	Pot. Saving EUR/Unit	Calculation Status	Total Pot. Saving OLT
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Figure 40 – Top 5 of Ongoing Ideas (HG1-4)

In order to perform this analysis, the RPP coordinator has to merge all OPLs in one Excel file and then, by using the filter function, he collects all the information needed. The time consumed to prepare the file, perform the analysis and build the monthly RPP report is around 2 days. Thus, it is important to mention that, although the objective was a monthly report, as this required a lot of effort compared with the evolutions presented, this report has been no longer carried out every month.

4.3 Improvement Proposals

As it was mentioned above, the two main objectives of this project are the design of the RPP process, seeking to optimise it by reducing waste and the construction of a dashboard that includes the performance indicators regarding RPP, allowing real-time monitoring. The proposals are explained below in more detail. Additionally, once again, for reasons of confidentiality and industrial property all information regarding the ratio project has been hidden or changed. However, the conclusions that have been reached have not been modified.

4.3.1 VSDiA application

RPP projects involve many members from other areas, thus leading to high response lead times. Although these projects have their prior planning, this planning sometimes suffers deviations, resulting in loss of opportunity and profitability for both the company and its customers. Bosch in Braga has a long experience with ratio projects and the responsible managers indicated that delays are recurrent, typically in initiatives triggered internally. As the collaborators involved in the ratio projects do not have as a main function the collaboration in cost reduction projects, this makes the lead time of the process even higher. Also, although there are some tools and some concepts that complement the RPP methodology, its process is not entirely clear and is only present in the head of the current RPP coordinator. Therefore, the analysis of the process of coordination of RPP projects was seen as an excellent opportunity for improvement. Then, in order to better understand the RPP processes, a workshop supported by VSDiA tool was carried out during the first phase of the project. The purpose of this workshop was to make the whole process more transparent, providing a better understanding to all stakeholders.

VSDiA Workshop Organization

To carry out the VSDiA workshop, it was required a meticulous organization. Firstly, several meetings were organized with the papers' authors and the company project team, in order to define the main workshop goals, stakeholders, relevant achievements and success criteria. Then, the official workshop VSDiA has been scheduled, involving every process stakeholder.

The official invitation has been sent to 21 attendees by e-mail. These attendees were grouped into 3 different groups:

- RPP coordinator – Responsible for coordinate all the activities regarding RPP
- Project Team – This team includes mainly the process line responsible and the testing project leader. Thus, these stakeholders are the ones responsible to execute the most tasks of this process.
- Controlling – The main input to this process from this stakeholder is the information about the RPP savings calculation.

The VSDiA workshop has resulted in the description of the process, the identification of improvement opportunities, wastes and non-value-added activities.

Current State Map Using VSDiA

The process mapping that was carried out allowed the acquisition of a detailed knowledge about the RPP processes. The current process map can be categorized into 3 different phases: (1) Idea Generation Phase (2) Preparation Phase (3) Implementation Phase.

1. **Idea Generation Phase**

This phase is the beginning of the process and is the phase where the product cost optimization ideas, that are the main input of this process, are generated. Ideas are generated through two different channels: RPP workshops or spontaneously (Appendix I).

On the one hand, workshops are organized by the RPP coordinator and take place on average, once a year. For each workshop, the RPP coordinator collects previously all the necessary and useful information (1) for the generation of ideas such as, for example, process overview (e.g., Line balancing charts, process flow) product technical overview from mechanical concept to the hardware diagram blocks. The workshop is also moderated by the RPP coordinator (2) and with the participation of the team (3), from development to production, which in turn, potential ideas for optimizing the cost of the product are raised, through brainstorming (4). On the other hand, spontaneous ideas are can be raised during follow-up meetings (8).

2. Preparation Phase

In the preparation phase, represented in Appendix II, there are still 2 possible paths depending on the source of the idea. If the idea comes from the workshop, the project team is responsible for assessing the feasibility of the proposal (6). In order to follow up the status, the RPP coordinator organizes follow-up meetings (5) until the answer regarding feasibility is received, which will determine whether the idea goes ahead (GO) or not (NO GO) (7). If the proposal is feasible, the decision is to GO and the idea is added to the Masterfile (10) where they are tracked. If the decision is NO GO, the idea is abandoned (9). If the idea is spontaneous, it will go directly to the Masterfile (10) and only then the feasibility analysis of the proposal is performed (11). During this analysis, the RPP coordinator will organize follow-up meetings in order to monitor the status of the idea until the project team has the feasibility analysis done. This analysis is communicated in the decision meeting where the idea will be rejected if it is not feasible or will be moved forward if it is feasible. At this stage, the two paths that existed previously converge.

Next, if an ECR is required to implement the idea, the process follows the standard ECR process (15), however, if not required, an alternative process is followed. The ECR process, complemented with the RPP tasks, is described in appendix IV.

Then the ECR process starts with the activity of creating and preparing the ECR (15.1) and then the preliminary agreement is made (15.2). After these two activities are performed, the masterfile is updated with the idea moving forward to HG 2 (15.3) and then, the process continues with the planning phase (15.4), where the Project Team should analyse the effort needed to implement the idea and provide the potential improvements that we will get. Then, a timeline should be created, achieving a planned introduction date. All this data is communicated to the RPP coordinator in the follow-up meeting (15.5 & 15.6). Next, the potential improvements are sent to controlling who will convert the improvements into savings (€) (15.7). During this activity some doubts arise, around 30% of the times, that end up requiring a review of the values provided. When the improvements are converted into euros, CTG (controlling) sends an email to the RPP coordinator. The RPP coordinator brings the team together and communicates the estimated savings and, compared to the effort required, a decision is made whether to proceed or abandon the idea (15.8). If the idea is not beneficial, the idea is abandoned and the HG is updated to 7 (15.9). If it is beneficial, the HG is updated to 3 (15.10) and we move on to the next phase. This phase is the event where the necessary validations are performed (15.11) and the customer is involved if necessary (15.12). After these two activities, we move on to the implementation phase (15.13).

If an ECR is not required, the process is quite similar. It starts in the planning phase (18), then data is communicated to the RPP coordinator (17 & 18) who will send to controlling for the calculation of the potential saving (19) and with that saving is evaluated, together with the project team, if the idea is beneficial or not (20). Then follows the implementation phase. If the idea is not beneficial the HG is updated to 7 (21) and if beneficial, the next phase is the idea implementation phase (22).

3. Implementation Phase

At this stage, presented in Appendix III, the measure is implemented (22). After the implementation, the Project Team collects the real improvements that resulted from the implementation, reporting to the RPP coordinator during the follow-up meetings (23 & 24). After the improvements are collected (25), the HG in the Masterfile must be updated to HG 4, the SAP must be updated (27) and the improvements must be prepared (26) and sent to controlling that will calculate the effective savings of the idea (28). Once the real savings are calculated, the RPP coordinator should insert them in the Masterfile and the HG has to be updated to HG 5, thus closing the idea and giving it as cost effective.

Currently, the execution of the whole process takes around 146.6 days, i.e., more than 6.6 months. This time is liable to be decreased by the elimination of non-value added activities.

Future State Map Using VSDiA

The future process is the result of several meetings held with the various departments and team members involvement, which aim consisted in mapping the future state of the process. The whole process was analysed in detail and the improvements were discussed and weighted. The following sections present the improvements in the processes.

1. **Idea Generation Phase**

On this phase, no opportunities for improvement were registered, therefore, the future state is the same as the current state.

2. **Preparation Phase**

On this phase, the improvements will be time reduction. Regular follow-up meetings would no longer be scheduled every two weeks but would be scheduled by the project team only when they have the desired output. This would lead to a reduction of unnecessary meetings. In addition, if the controlling department sends, for example at the beginning of the year, some estimates of the conversion of potential improvements into savings, the RPP manager will be able to get an idea of the potential savings without having to go to the CTG department. These savings will be later calculated and confirmed by CTG but at this stage it is thought that these estimates will be sufficient for the purpose and will make the process more efficient.
The future state of this phase is represented in appendix V.

3. **Implementation Phase**

On this phase, the improvements will be time reduction and at information level. Regular follow-up meetings would no longer be scheduled every two weeks but would be scheduled by the project team only when they have the desired output. Then, before the improvements are sent to controlling there should be an update of the new KPIs in the system thus enabling the controlling department to visualise the improvements made. The future state of this phase is represented in Appendix VI.

4.3.2 Dashboard

Organisations seek to analyse data and information as intuitively and practically as possible, so that their decisions are as quick and accurate as possible. In this way, information that is schematised, timely and correct information is of enormous importance, since decision making is fundamental for the sustained growth of organisations.
The fact that the current status analysis and reporting process is very time consuming and requires a lot of effort from the RPP coordinator to perform it, the construction of a systematic

and a tool that could optimise this procedure was seen as an excellent opportunity for improvement.

Business Intelligence systems emerge as mechanisms that increase value to the current information systems of organisations, through the combination of data from different sources, making them available in a simplified and timely manner to the decision maker, thus facilitating decision making.

The construction of the dashboard had as main premises the ease in updating the information, as well as the automation of the way in which the data is imported. For the implementation of the dashboard, it was necessary to learn a new software, which required a significant part of this research project.

The steps taken during the creation of the dashboard are presented below, as well as how the dashboard is structured.

Dashboard construction steps

The construction of the dashboard consisted of the following steps:

1. Software selection
2. Data collection and preparation
3. Dashboard creation

Software selection

After analysing the various options, the software chosen was Microsoft Power BI. This decision was supported by the ease of acquisition of the software since it comes included in the Office package to which most companies have access. Another important factor, which supported the decision, was the fact friendly software, i.e., of accessible interpretation and use, and also because it allows it use in several platforms, whether desktop, tablet or smartphone.

Data collection and preparation

The second stage consisted of understanding the methodology used, as well as understanding which metrics were most relevant for this analysis. For this, a benchmarking was performed in order to find the most commonly key performance indicators used in project management.

Then, it was found that the relevant information was recorded in several non-standard Excel files. So, the first step was to migrate the data into standard excel files, known as master files. In total there are 11 of them, which means that are 11 different sources. The next step was to identify which data from each of the sources would be relevant for the analysis, extracting only those that were necessary for the dashboard, so as not to overload the system with unnecessary information.

Dashboard creation

The last stage consisted of creating the dashboard in Power BI. In this stage, the various pages of the dashboard were structured a way to contain the indicators required for analysis, as well as a set of filters and segmentation of data that allow different types of analysis, according to the requirements that the user defines at each moment of analysis.

Dashboard structure

The dashboard is structured as follows:

A. RPP Overview
B. RPP Measures
C. RPP Running Total
D. RPP TOP
E. RPP Report data
F. Data quality

In the following, each of the dashboard pages will be explained using print screens for better understanding.

A. RPP Overview

The dashboard homepage is intended to be, as the name implies, an overview of the RPP status. Figure 41 shows the dashboard's home page. Then, each of the numbered sections in Figure 41 is described.

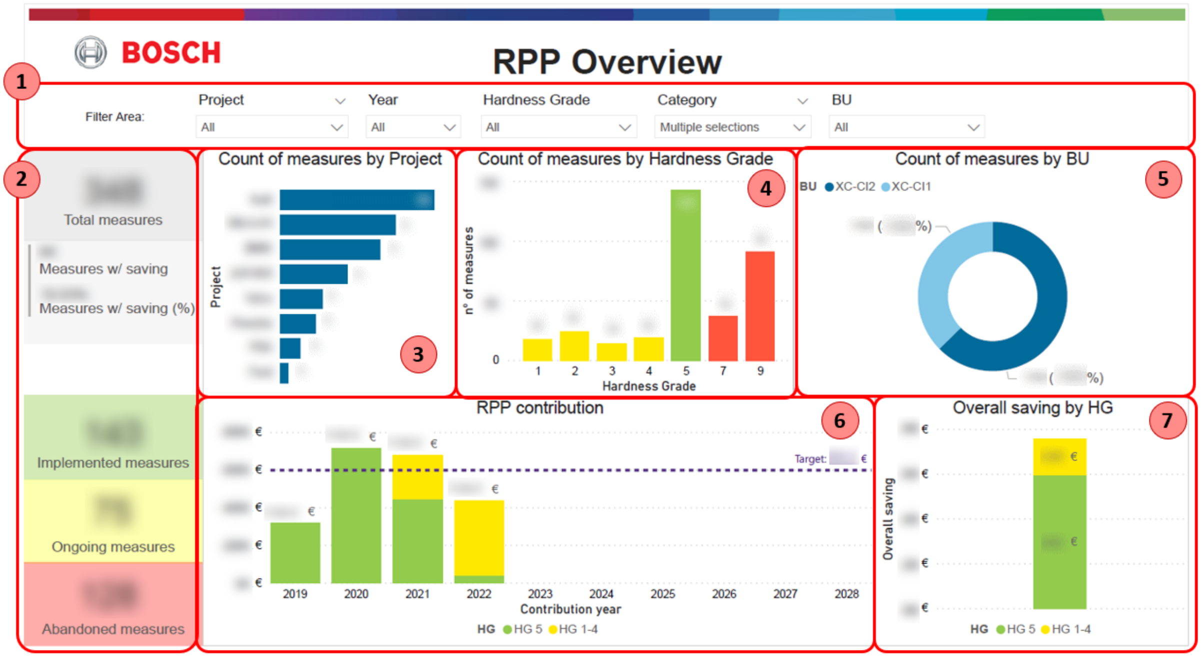

Figure 41 – RPP Overview

1. **Filter Area:** In this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

   - <u>Project</u> (example, BMW, Ford, RN A-IVI…)
   - <u>Year</u>, corresponding to the measures' implementation year.
   - <u>Hardness Grade</u>, that represents the stage of progress of the measure (example, HG1, HG2, HG3, HG4, HG5, HG7, HG9)
   - Measures' <u>category</u> (example, MAT: Material; VA: Value Add)
   - <u>Business unit</u> (example: XC-CI1 or XC-CI2)

2. **Data segmentation and information cards**: on the other hand, in section 2 it is possible to observe general information regarding the data analysed, such as, the total number of measures, the number of measures that have savings and the respective percentage. Bellow, it is possible to verify, of the total number of measures, how many are already

implemented, in the green card, how many are ongoing, presented in the yellow card and, finally how many were abandoned, visible in the red card.

3. **Count of measures by project:** this graph presents the number of measures by projects, allowing analysis of which projects have the most and which have the fewest number of measures regarding the RPP.

4. **Count of measures by HG:** presentation of an overview of the phases in which the measures are.

5. **Count of measures by business unit (BU):** this graph shows the number of measures by BU, and the respective percentage, allowing analysis in order to compare which business unit have more measures, and which have less measures regarding the RPP.

6. **RPP contribution:** this bar chart allows the analysis of potential savings, some already effective (HG5) and others still pending (HG1-4) in terms of RPP, across several years and with the annual target, represented by the purple horizontal line.

7. **Overall saving by HG:** represents the total potential savings until end of production of the projects, also with some savings already effective (HG5) and others still pending (HG1-4)

B. RPP Measures

The next page is RPP Measures, and this page aims to present, in a more detailed, informative and descriptive way, all the RPP measures and is represented in the figure below.

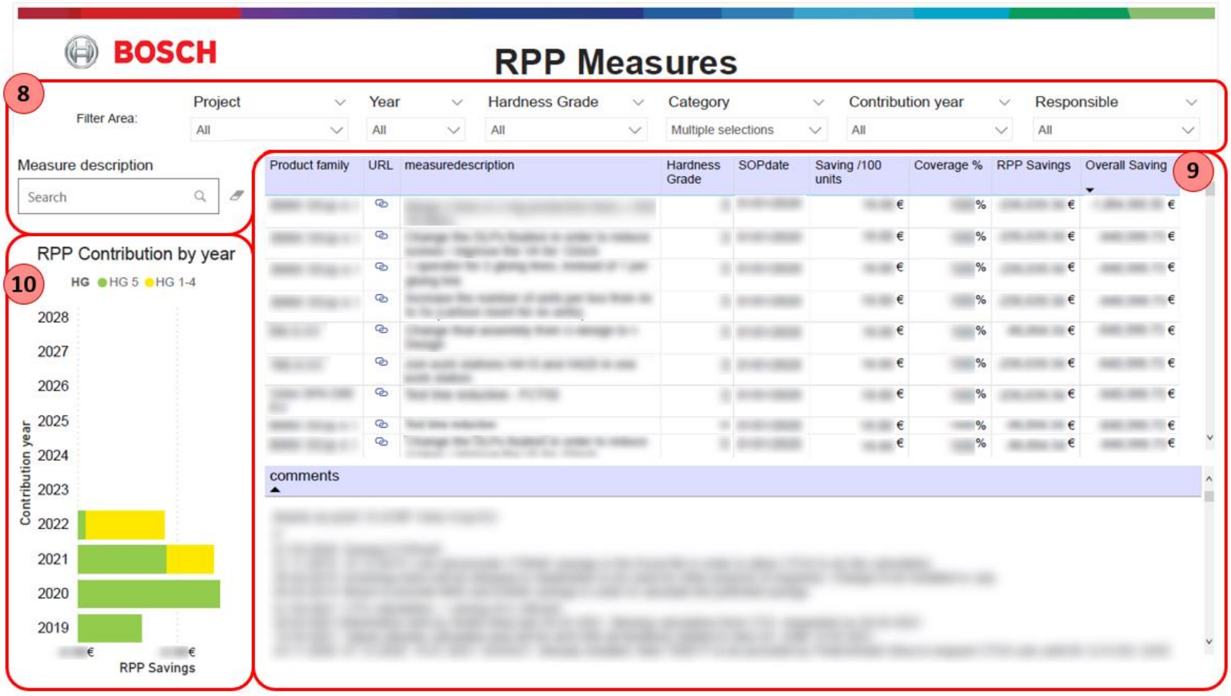

Figure 42 – RPP Measures

8. **Filter Area:** in this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

   - <u>Project</u> (example, BMW, Ford, RN A-IVI…)
   - <u>Year</u>, corresponding to the measures' implementation year.
   - <u>Hardness Grade</u>, that represents the stage of progress of the measure (example, HG1, HG2, HG3, HG4, HG5, HG7, HG9)
   - Measures' <u>category</u> (example, MAT: Material; VA: Value Add)
   - <u>Contribution year</u>, which corresponds to the year that the measure contributed in terms of RPP.
   - <u>Responsible</u>, which is the employee in charge of the measure.
   - <u>Measure description</u>. If known, it is also possible to find the measures by name through the search text box.

9. **Measures' description:** this table shows the most relevant data for each measure. In the first column is described the project identification and in the second column is a link that, after selected will redirect to the respective Masterfile that is, in this case, the source of the data. In the third column is the description of the RPP measure followed by the respective Hardness Grade in the next column. Continuing, the SOP date column contains the measure's implementation date, which means, the date since when the measure started to contribute in terms of RPP. Following, it is also possible to see the respective saving/100 units of each measure, the coverage %, which represents the percentage of the project's volume that is affected by the measure, the RPP savings that indicates the potential savings in terms of RPP and, finally, the saving until the end of production represented in the overall saving column. Below, it is possible to see the comments and the follow-up of the RPP measures.

10. **RPP Contribution:** on the left side, in section 10 is represented the RPP contribution across the years is represented. This graph is similar to the one presented in the overview page and aims to help visualise the impact of the measures described in section 9.

C. RPP Running Total

The next page is the RPP Running total, and the goal of this page is to present the forecast regarding RPP savings for the end of the selected year. The RPP Running total page is represented in the figure below.

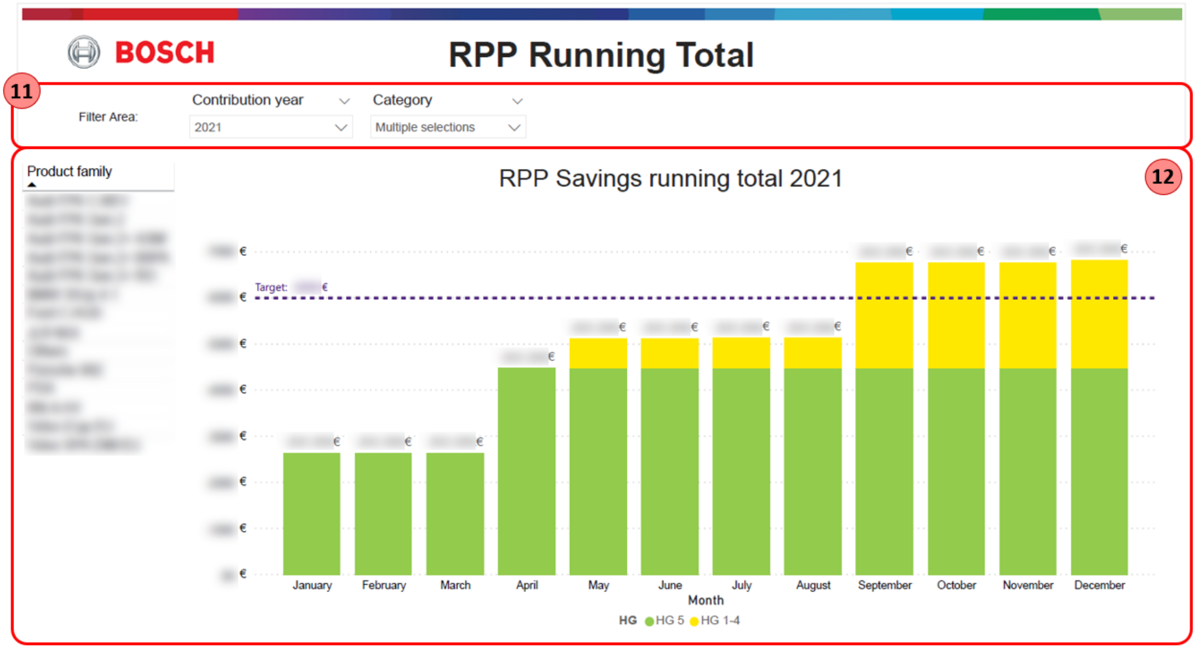

Figure 43 – RPP Running Total

11. Filter Area: in this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

- Contribution year, which corresponds to the year that the measure contributed in terms of RPP.
- Measures' category (example, MAT: Material; VA: Value Add)

12. Cumulative Forecast: in this section 8 is shown a list of the products families on the left side and on the right side, a graph that shows the cumulative forecast, effective (HG5) and pending (HG1-4) potential savings throughout the year and the annual target (€), represented by the purple horizontal line. The title will update automatically according to the contribution year selected in the filter area.

The product family list allows the user to select one or more projects and see their RPP savings highlighted in the graph on the right. As an example, in the figure bellow, is possible to see the RPP savings from BMW 35Up4.1 highlighted within the total RPP savings from 2021.

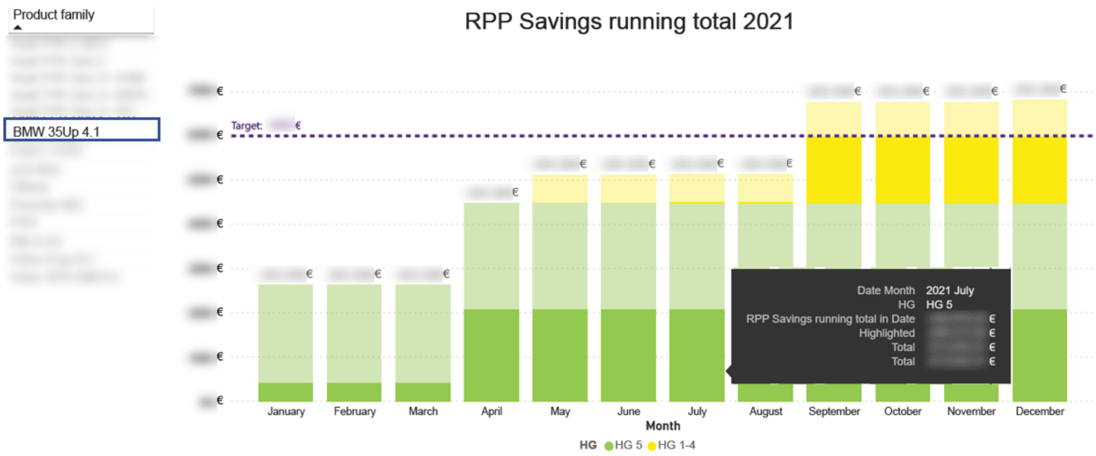

Figure 44 – Running Total highlighted

D. Other KPI

The next page is named Other KPI. This page was created to present some relevant analyses that were not previously carried out as they had to be done manually, making the process too consuming. The main analysis of this page is the count of measures by calculation status, the count of measures by responsible and the presentation of the measures that already past the deadline, meaning that are overdue. The page is represented in the figure below.

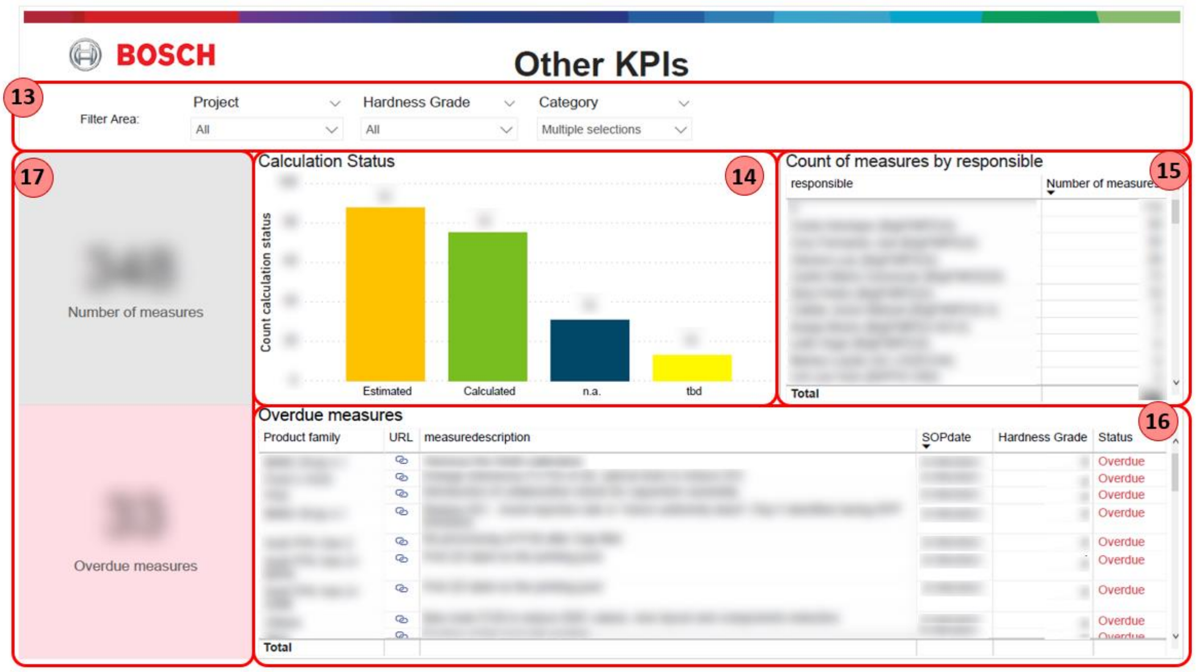

Figure 45 – Other KPIs

13. **Filter Area:** in this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

- Project (example, BMW, Ford, RN A-IVI…)

- Hardness Grade, that represents the stage of progress of the measure (example, HG1, HG2, HG3, HG4, HG5, HG7, HG9)

- Measures' category (example, MAT: Material; VA: Value Add)

14. **Calculation Status:** this bar graph shows the number of measures per calculation status. This chart aims to present the number of measures that have calculations to be performed, represented in the tbd (to be defined) column, the number of measures estimated by the project team, represented by the estimated column and those calculated by CTG (controlling)., represented by calculated column. The n.a. column refers to measures for which the calculation was not applicable. Note: measures that do not have the calculation status field fulfilled, does are not presented.

15. **Responsible**: this table presents the number of measures by responsible. The main purpose of this table is to analyse capacities, such as work overloads. When a measure does not have a responsible written in the Masterfile, the dashboard will count as a 0.

16. **Overdue measures:** this matrix shows the measures that have passed the deadline date and are still open (HG1-4) and the measures that do not even have a deadline date and are also open (HG1-4). This matrix will allow a better control of the measures' deadlines, thus avoiding that they fall into oblivion and missing the opportunity to obtain more savings for the company.

17. **Information cards:** the card on the top, represents the total number of measures and the bottom one shows the number of measures that have passed the implementation deadline and are still open.

E. RPP TOP

This page is RPP TOP, and the aim of this page is to present the top measures by overall savings and is represented in the figure below.

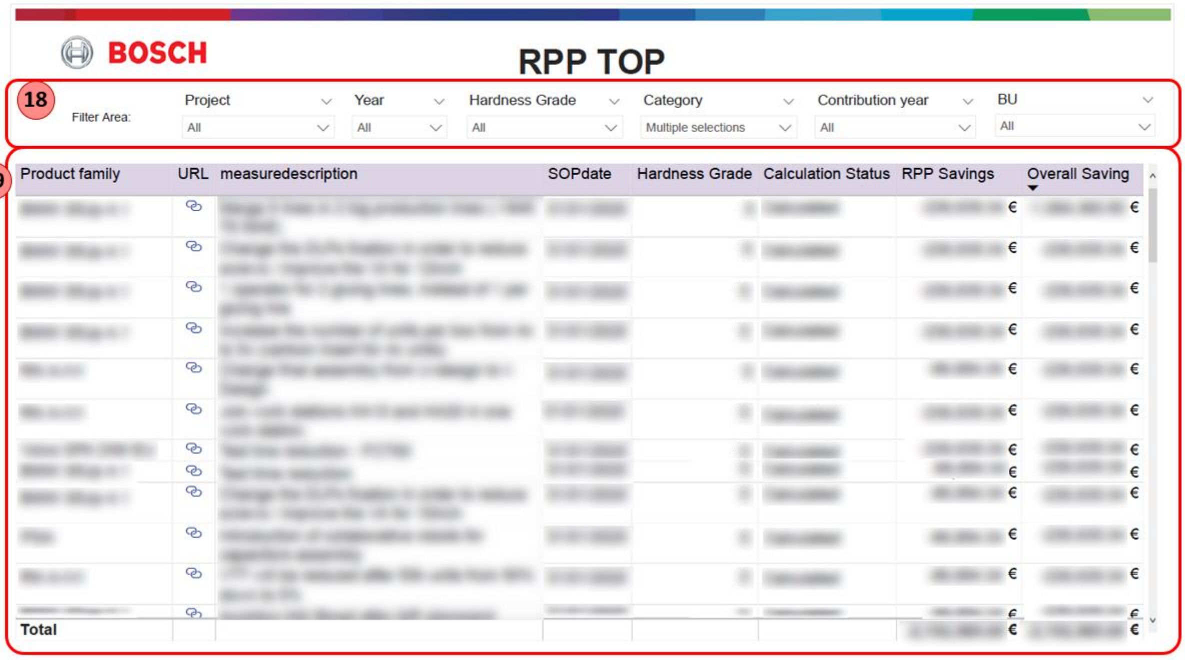

Figure 46 – RPP TOP

18. Filter Area: in this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

- <u>Project</u> (example, BMW, Ford, RN A-IVI…)
- <u>Year</u>, corresponding to the measures' implementation year.
- <u>Hardness Grade</u>, that represents the stage of progress of the measure (example, HG1, HG2, HG3, HG4, HG5, HG7, HG9)
- Measures' <u>category</u> (example, MAT: Material; VA: Value Add)
- <u>Contribution year</u>, which corresponds to the year that the measure contributed in terms of RPP.

- Business unit (example: XC-CI1 or XC-CI2)

19. **Top measures:** in the top measures table is possible to observe the top measures sorted in descending order by overall saving. This is one of the tables used in the monthly report, hence the importance of its representation. This table shows the project to which the measure refers, the measure description, the implementation date (SOP date), the hardness grade, the calculation status, the savings in terms of RPP and the overall saving. Additionally, there is, one more time, the link in each measure that, once selected, will redirect to the data source, the Masterfile where the regular follow-up is performed.

F. RPP Report data

The next page is RPP report data and, as the name implies, presents data that, at the current date, are reported in the monthly meetings to the management This page is shown in the figure below.

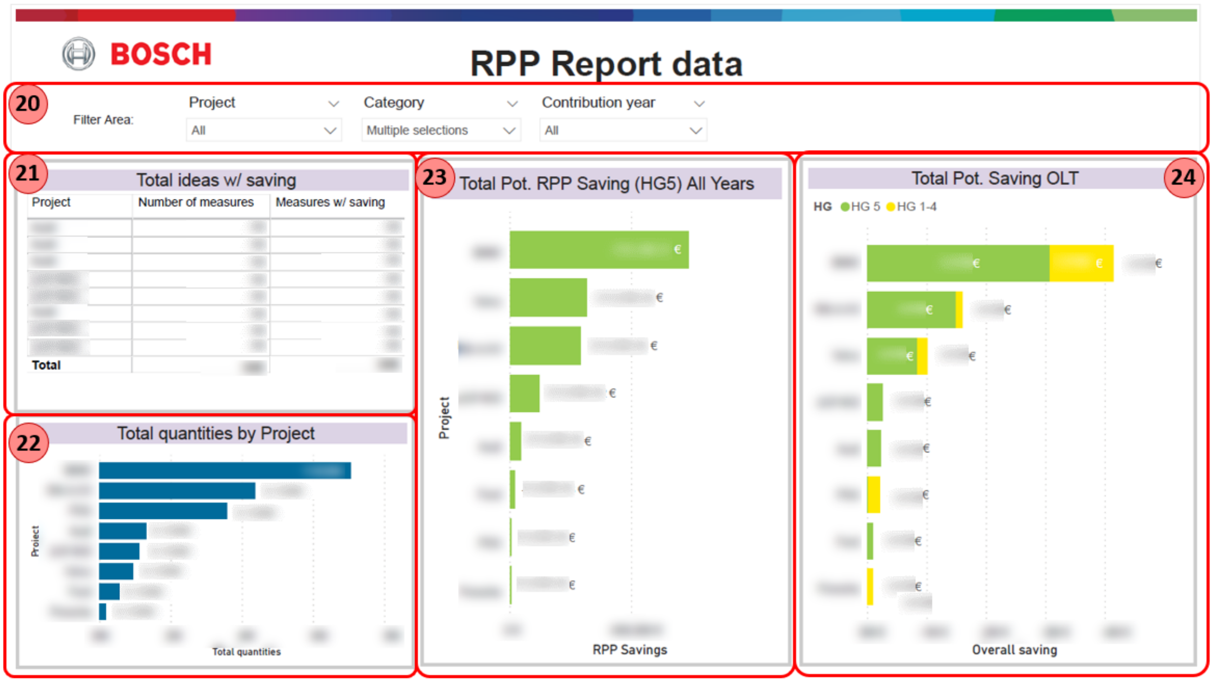

Figure 47 – Report data

20. **Filter Area:** in this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

- Project (example, BMW, Ford, RN A-IVI…)

- Measures’ category (example, MAT: Material; VA: Value Add)

- Contribution year, which corresponds to the year that the measure contributed in terms of RPP.

21. **Total ideas with saving:** this table indicates the total number of measures per project and how many of these have saving.

22. **Total volume per Project:** graph with the total volume per Project until the end of series.

23. **Total Pot. RPP Savings (HG5):** graph that shows the savings in terms of RPP per project for measures with HG 5, i.e., those already implemented and cost effective. To check, for example the RPP savings from 2021, the year 2021 in contribution year filter should be selected and the graph and the respective title will update automatically. If no contribution year is selected, the graph shows the RPP savings for all years.

24. **Potential savings over lifetime**: the chart on the right shows the potential savings over lifetime, for measures HG5, i.e., implemented, but also for measures with HG1-4, i.e., still ongoing.

G. RPP Masterfile Data quality

The following page is RPP Masterfile Data quality. This page is shown in the Figure 48. The need to create a page that would allow monitoring the correct fulfilment of data was something that arose given its importance. In order to obtain correct, complete and efficient analyses, it is necessary to have good quality data.

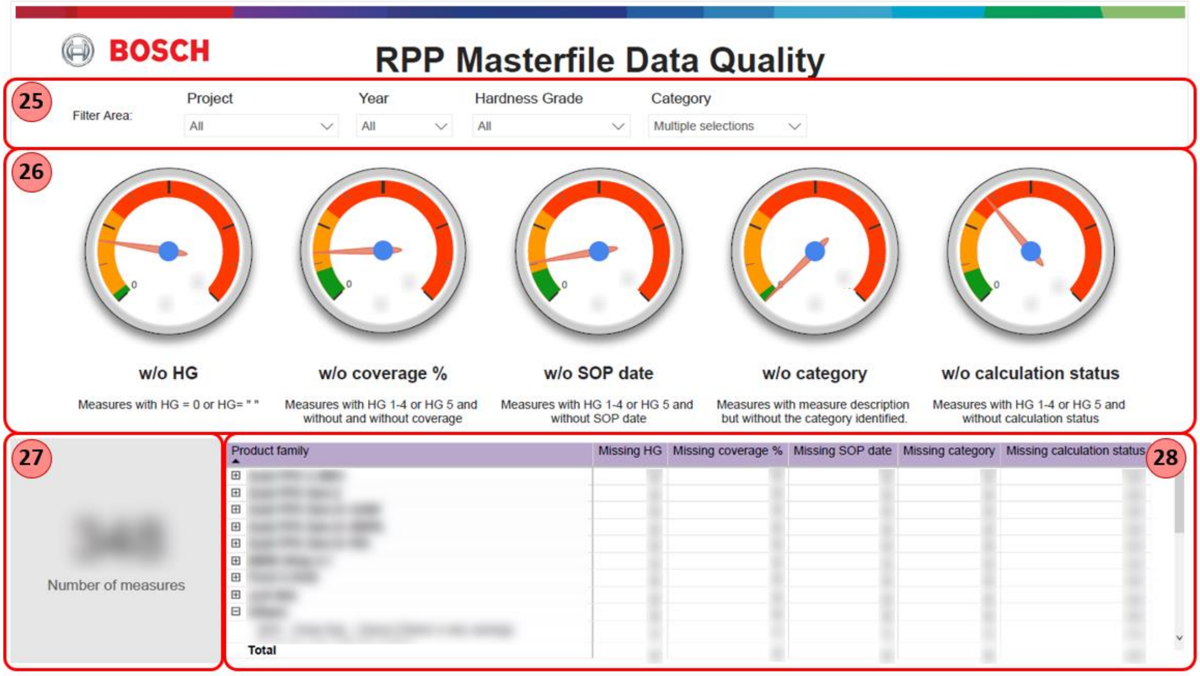

Figure 48 – RPP Masterfile Data Quality

25. Filter Area: in this section, it is possible to filter the data to carry out different analyses. The data can be filtered by:

- <u>Project</u> (example, BMW, Ford, RN A-IVI…)
- <u>Year</u>, corresponding to the measures' implementation year.
- <u>Hardness Grade</u>, that represents the stage of progress of the measure (example, HG1, HG2, HG3, HG4, HG5, HG7, HG9)
- Measures' <u>category</u> (example, MAT: Material; VA: Value Add)

26. Dial gauges: the different dial gauges, in section 26, indicate the number of unfilled fields for HG, coverage %, SOP date, category and calculation status, through the following measures:

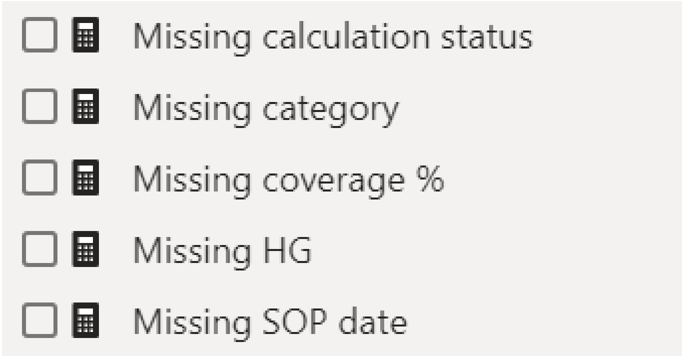

Figure 49 – Unfilled fields calculation measures

Then, each graph has a green range (good), a yellow range (satisfactory) and a red range (unsatisfactory). The intervals change from chart to chart as they depend on the level of severity. For example, a measure without HG has more severe consequences than a measure without calculation status, therefore the limits are lower. These limits are arbitrary and may be changed, for example due to data quality developments, and are represented by the following measures:

Figure 50 – Dial Gauge arbitrary limits measures

27. **Information cards:** this card that indicates the number of measures being analysed.

28. **Measures with data to be filled:** this matrix that shows the total number of measures per project that do not meet the requirements described above. The number 0 means that the respective measure or project fulfils the requirements, so the fields are filled. If it has the number 1, it means that the field does not fulfil the requirements, meaning that it is not filled in. Also, if the plus sign to the left of each project name is selected, the breakdown of measures will be shown.

5. Analysis and Discussion of the Results

This chapter presents the critical analysis and discussion of the results of the case study. There is also the interest in comparing the activities in this RPP methodology with the concepts approached by the cost reduction literature and by project management literature for the same objective.

5.1 Convergence between cost reduction literature and the RPP methodology

The analysis of this case made evident that there is a parallelism between the concepts addressed in the academic literature on cost reduction and the practices and approaches adopted by the Bosch company. Many of the characteristics of the cost reduction systems described in chapter 2 are present in the activities developed at Bosch.

Then, some aspects that show that the RPP approach can be classified and within the scope of cost reduction methodologies applied in modern companies, are highlight.

Table 2 – Comparison between cost reduction methodologies

	Target Costing	**Kaizen Costing**	**RPP**
Application stage	Development phase	Production phase	Production phase
Goal	Focus on the product. Cost reduction is achieved through product design.	Focus on production processes. Cost reduction is achieved primarily throughout the increased efficiency of production processes.	Focus on production processes. Cost reduction is achieved primarily throughout the increased efficiency of production processes.
Scope of application	Product-specific	Period-specific Product-specific Overhead specific	Period-specific (subtractive approach)
Tools	DFMA (Design For Manufacturability and Assembly) VE (Value Engineering)	VA (Value Analysis)	VA (Value Analysis)

	QFD (Quality Function Deployment)		
Characteristics	Cost reduction culture Established Target Price	Cost reduction culture Continuous improvement mindset	Cost reduction culture Continuous improvement mindset Cost reduction applied in project format

As it is possible to verify through Table 2, the Ratio Project Planning (RPP) methodology relates easily with Kaizen costing as both methodologies occur during the production phase of a product, unlike Target Costing that is applied during the product development phase.

While Target Costing focus on the product and cost reductions are achieved through product design, kaizen costing and RPP focus on production processes. In this case, the cost reduction is achieved primarily throughout the increased efficiency of the production process (Modarress et al., 2005).

Regarding the scope of application of each methodology, the Target Costing adopts the product-specific approach since this methodology focus more on product design. On the other hand, Kaizen Costing has three main approaches, namely period-specific, product-specific and overhead-specific level. The period-specific approach focuses on reducing the cost of production processes over a predetermined period while maintaining the company's profitability levels. The product-specific approach, besides being one of the approaches of target costing, is also of Kaizen costing. This approach is applied when a new product starts being produced, despite not meeting the costing targets, set in the development phase, for various reasons. This approach can also arise at this stage in situations such as when the sales price stipulated during the development phase for a new product decreases faster than expected. The third kaizen costing approach, overhead-specific, focuses on indirect costs, while period-specific and product-specific kaizen costing focuses on direct costs. The RPP methodology, on the other hand, uses only the period-specific approach, more specifically, a subtractive approach, since the company stipulates cost reduction targets by year, passing this information on internally until it reaches each work group (Cooper & Slagmulder, 1999).

Concerning the tools used in each methodology, the Target Costing stands out with three particularly important, which are DFMA, VE and QFD. These tools are associated with design for manufacturability and assembly, design for inspection and testing, modularity and standardisation of parts, and value analysis or function analysis (Ibusuki & Kaminski, 2007).

In contrast, both Kaizen Costing and RPP use a VA tool, seeking to improve the manufacturing process rather than products. In other words, value analysis quantifies the level of waste existing in a given production process and reduce or eliminate them without impairing the quality, and functional reliability (Ramezani & Razmeh, 2014).

Then, when analysing some characteristics of the three methodologies, we find that they all confirm the need to have a culture in the company focused on cost reduction. This is a fundamental change from the attitude in most organizations and it is the most challenging step. RPP is a good tool, but it needs to be part of a wider organizational culture on continuous improvement, thus, part of the company's strategy and philosophy. On the other hand, while Target Costing seeks to reach a target price through the tools mentioned above, Kaizen costing and RPP only seek to optimise the cost of the product in a continuous way, and for this it is important to have a continuous improvement mindset. One of Bosch's main concerns is the continuous improvement in its processes and methodologies, and RPP is a very important tool to achieve this goal. The concept of continuous improvement in the academic literature comes from the Kaizen philosophy, which includes Kaizen Costing. Monden (1995) also mentions the importance of planning the costs of a company's activities in the form of a budget, taking into consideration the Kaizen Costing objectives developed in the company.

Finally, one of the aspects that characterises the RPP methodology is the application of cost reductions through the project format. The search for continuous improvement in this case is then achieved through the implementation of various projects, each with a beginning and an end date well defined. Cost management and cost reduction projects are normally the responsibility of multidisciplinary teams set up for this purpose. In fact, according to the literature (Bragg, 2010), the application of cost reduction through projects, allows the achievement of cost reduction objective in a more effective and organized way. This is one of the most important issues in this case study, as the RPP methodology suggests this approach. At Bosch, projects can be initiated by company associates or even with external input, from customers, for example, in order to explore opportunities for cost reduction. In RPP projects, it is possible to verify the phases of the life cycle of a project as defined by PMI as best practices in project management. The phases in the RPP are assessed using the Hardness Grade and correspond to the five project management processes (Table 3).

Table 3 – Comparison between RPP and Project Management process groups

RPP	PMI
HG1 – Idea	Initiating Process
HG2 – Planning phase	Planning Process
HG3 – Implementation phase	Executing Process
HG4 – Production process approved	Monitoring and Controlling Process
HG5 – Cost effective	Closing Process

HG1, which is the initialisation process, comprises the process of defining a new project based on a cost reduction idea. Then, in HG2, the project planning is carried out and at this stage it is defined the course of action required to achieve the objectives for which the project was designed, particularly in terms of the resources required and expected duration of the project. The next phase, HG3, is the execution phase. This process is performed to complete the work defined in the project management plan to satisfy the project requirements. Then, at the HG4 stage, the monitoring of the status of the cost reduction project is carried out through regular meetings, identifying any areas in which changes to the plan are required and, if necessary, the corresponding changes are initiated. Finally, HG5, corresponds to the project closure phase, a phase in which the cost reduction project has been fully implemented and is already contributing to the profitability of the company.

After analysing the three methodologies, it is possible to verify several similarities between them, being Kaizen costing the methodology that most identifies with RPP. On the other hand, one of the highlights of RPP is to support continuous improvement in a discrete way, i.e., through projects. So, continuous improvement asks for projects which have a clear beginning and end, and it is precisely the sum of those different projects that allow continuous improvement to be effective. On the other hand, RPP can also be seen, in a way, as a materialisation and adaptation of Kaizen costing for the context of western companies.

5.2 Validations

This section aims to analyse the results of the proposed improvements and whether they achieved the speculated performance in practice. In addition, in this section it is also verified whether the two proposals developed (VSDiA and RPP dashboard) satisfy the needs of the organisation.

5.2.1 VSDiA

Besides the goal of describing the RPP process and making it more transparent and clearer for the project team, VSDiA also aimed to optimize it. Then, in order to understand if these initially outlined objectives were met, the following analyses were performed:

RPP process Lead time

With the improvements to be implemented that were obtained from the vision of the future state, the future process will take 96.6 working days, i.e., approximately, 4.4 months (Table 2), which represents a significant time reduction and a relevant increase in process efficiency and performance.

Table 4 – Time comparison between current and future processes

Time	Current process	Future process	Decrease
Lead Time	146.6 days	96.6 days	34 %

Survey

In addition, a survey was prepared (APPENDIX VII – SURVEY N.01 – RPP VALUE STREAM MAPPING), which allowed obtaining an opinion from those involved, mainly with the aim of understanding whether the VSDiA provides a better overview of the RPP process. The survey was submitted to 8 people who will use the VSDiA as a tool to support the execution of their activities. The survey consists of 2 questions, all with 5 possible answers, ordered by degree of agreement (1- I do not agree to 5- I totally agree). The results of the answers are shown in Figure 51 and Figure 52.

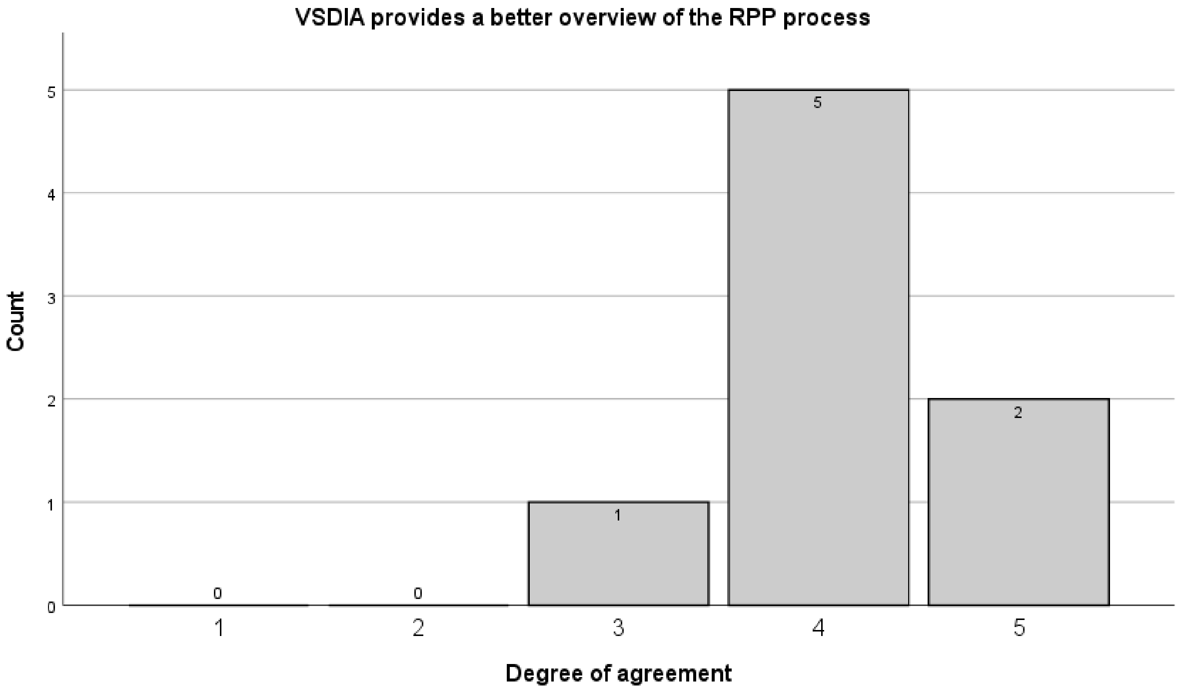

Figure 51 – Answers to question 1 of survey nº01

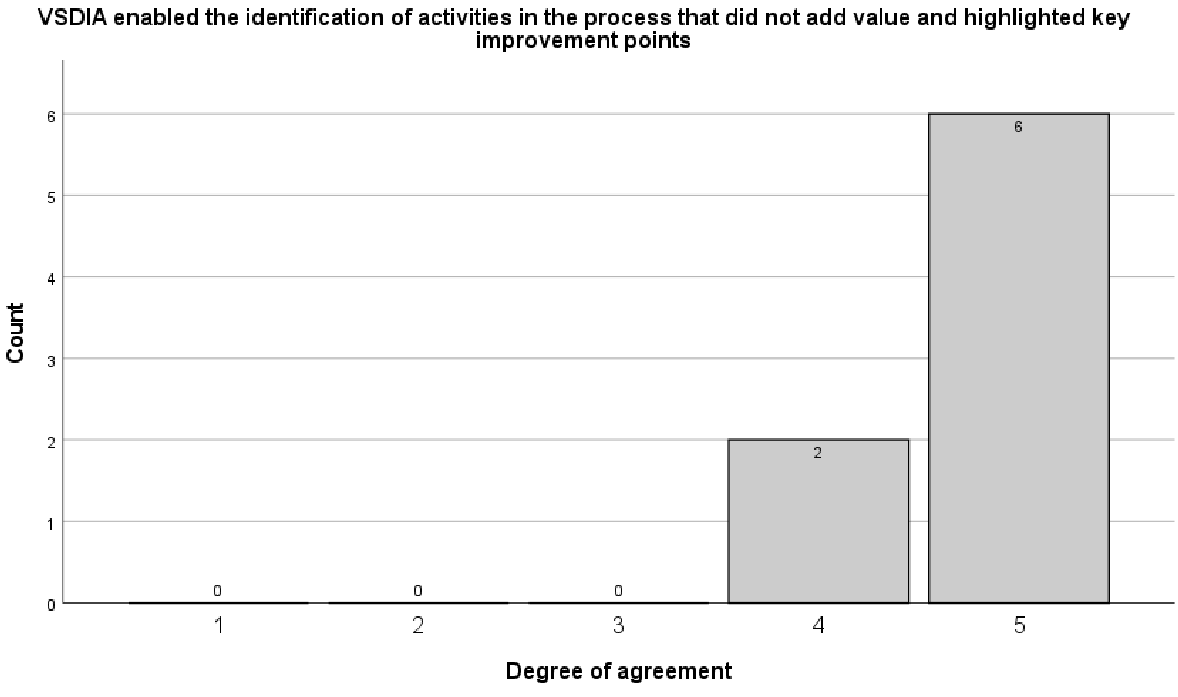

Figure 52 – Answers to question 2 of survey nº01

Based on the results presented above, it can be seen that the main objectives defined were met, with VSDiA being an advantage to the RPP process.

5.2.2 Dashboard

As previously mentioned, the main goals to be achieved with the implementation of the Dashboard were to make available correct and timely information, which would allow a more efficient analysis and monitoring of the current status of the RPP projects and, on the other hand, would allow supporting the monthly report.
In order to understand if these initially outlined objectives were met, the following analyses were performed:

Time to perform the report

Previously, as it was mentioned above, in order to perform the analysis shown in the report, the RPP coordinator has to merge all OPLs in one Excel file and then, by using the filter function, he collects all the information needed. The time consumed to prepare the file, perform the analysis and build the monthly RPP report is around 2 working days. Thus, it is important to mention that, although the objective was a monthly report, as this required a lot of effort compared with the evolutions presented, this report has been no longer carried out every month. With the implementation of the dashboard, it is possible to obtain analyses automatically, reducing the time needed to build the report to around 1 hour.
These results represent a total of about 180 hours saved throughout the year, which, based on the current indirect employee cost rate, corresponds to about 3 620 €/year.

Data quality

Regarding data quality, previously there was no monitoring. However, in order to obtain correct analyses, it is necessary that the data is well filled. With the implementation of the dashboard, it was possible to monitor the data used in the analyses, thus ensuring a better data quality.

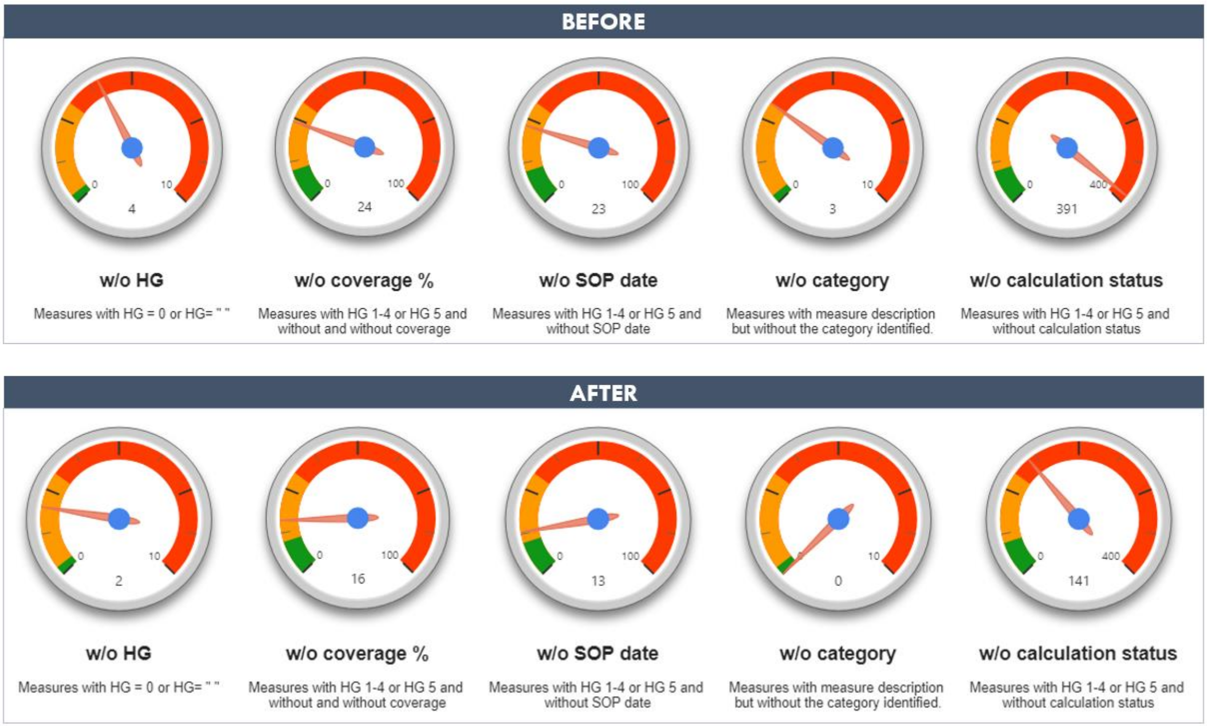

Figure 53 – Validation Data quality

As can be seen in Figure 53 and in Table 3, after only two months of implementation of the Dashboard, it was possible to verify an improvement in the quality of the data in all the topics evaluated and essential for the analyses.

Table 5 – KPI comparison between before the use of the Dashboard and after the use of the Dashboard

KPI	Before Dashboard	After Dashboard	Decrease
Hardness Grade (HG)	4	2	50 %
Coverage %	24	16	33 %
SOP date	23	13	43 %
Category	3	0	100 %
Calculation Status	391	141	64 %

Overdue measures

Just as there was no tool to evaluate the quality of the data, there was also no tool to detect which projects had exceeded the expected implementation date. With the implementation of the dashboard, it is possible to detect these projects and then take the necessary decisions, avoiding the loss of opportunity costs. The results are presented in the figure bellow.

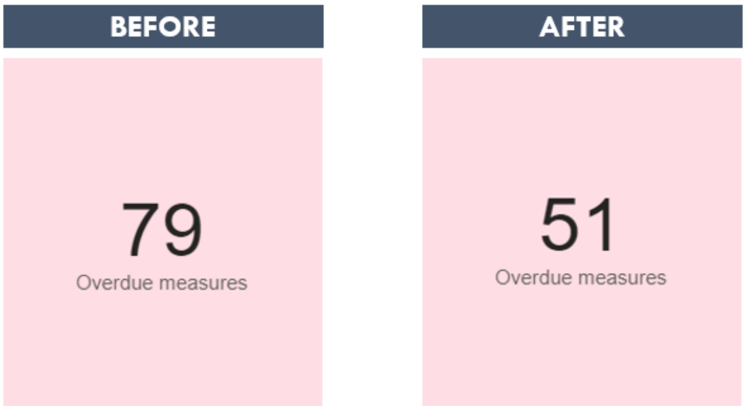

Figure 54 – Validation Overdue measures

As can be seen, before the implementation of the Dashboard there were 79 projects where the planned implementation date had been exceeded. After implementation, there was a reduction of 28 projects with overdue dates which corresponds to an improvement of about 35%.

Survey

In addition to the indicators mentioned above, a survey was prepared (APPENDIX VIII – SURVEY N.02 – RPP DASHBOARD EVALUATION), which allowed obtaining an opinion from those involved, mainly with the aim of understanding whether the dashboard is user friendly and contains only relevant information. The survey was submitted to 8 people who will use the dashboard as a tool to support the execution of their activities. The survey consists of 3 questions, all with 5 possible answers, ordered by degree of agreement (1- I do not agree to 5- I totally agree). The results of the answers are shown in Figure 55, Figure 56 and Figure 57.

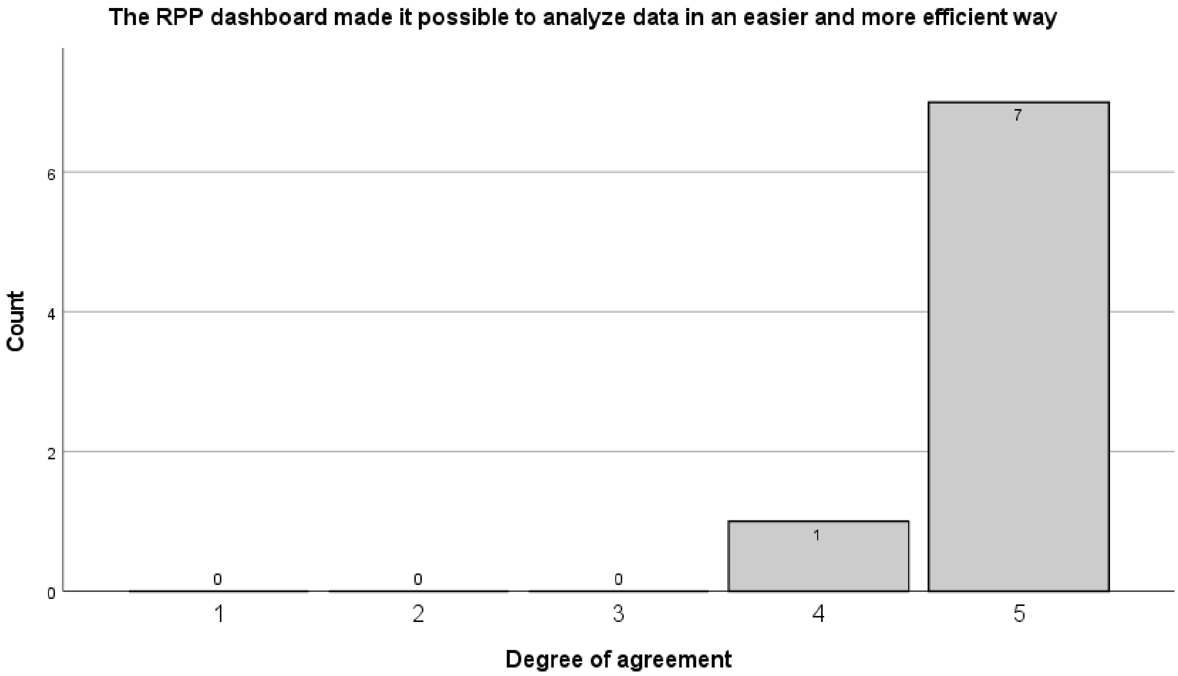

Figure 55 – Answers to question 1 of survey nº02

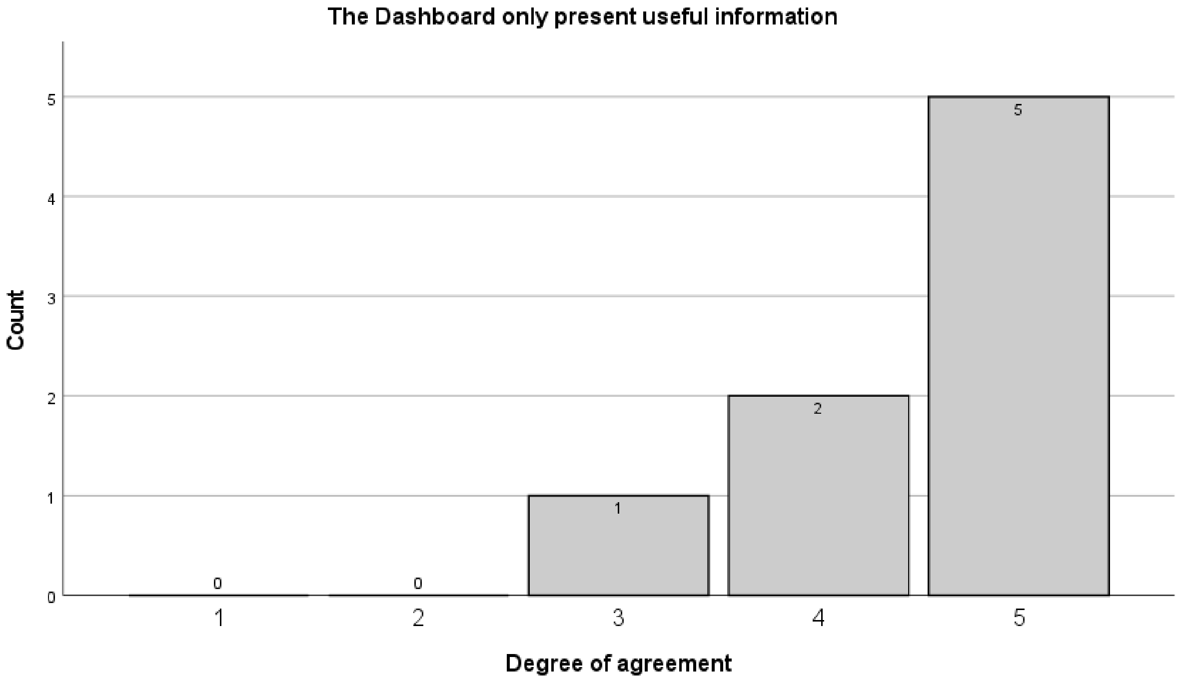

Figure 56 – Answers to question 2 of survey nº02

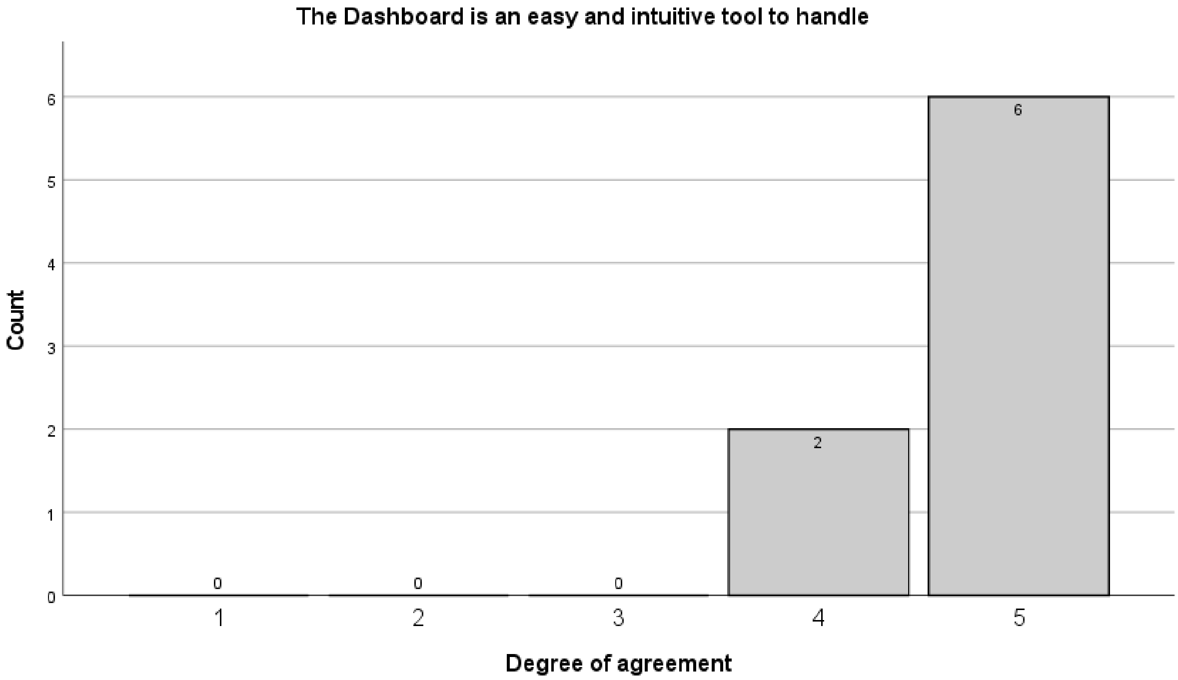

Figure 57 – Answers to question 3 of survey nº02

Based on the results previously exposed, it is possible to see that all the objectives defined were met, with the dashboard being an easy-to-use tool that comprises only useful information, thus being an added value to the RPP process.

Still regarding the dashboard, based on the feedback received from some senior managers of the RPP process, it is in their interest to apply this tool to other plants located in other countries, such as Germany, China and Malaysia as they saw a lot of potential in this tool.

6. Conclusions

This last chapter presents the main conclusions obtained in this research project. Also, some limitations of the project are highlighted and some opportunities for future work are identified.

6.1 Final considerations

In order to study the applicability of the cost reduction systems proposed by the literature, the *Ratio Project Planning* (RPP) methodology of the company Bosch was analysed. Since the beginning of the research project, it became clear that there is a strong parallelism between the literature on cost reduction in the production phase, particularly kaizen costing, and the practices at Bosch. Like kaizen costing, the RPP methodology is applied at the production phase, it is focused on continuous improvement and uses value analysis tools in order to implement product cost optimization ideas. On the other hand, according to the kaizen costing literature, cost management and cost reduction projects are normally the responsibility of multidisciplinary teams set up for this purpose. In Bosch's case, there are no teams exclusively dedicated to product cost optimisation projects. The RPP is secondary for most of the team members, thus reducing the priority of the completion of activities. The postponement of these activities leads to project delays and decreases potential gains. However, the fact that the RPP teams are the project teams responsible for the industrialisation of a given product, they already have a background on the project and also have a greater and more specific know-how on the product and the process, thus allowing more detailed analyses, unlike what would happen if there was a team responsible for the cost optimisation of all products.

This research project aimed to improve some procedures, which were not performing efficiently enough, being responsible for several financial losses. Furthermore, the company did not have any mechanism that would allow the main stakeholders to have easy and quick access to information, which compromised a justified decision making supported by facts. Based on this diagnosis, some improvement proposals were suggested to the organization which, in general, were well accepted by the various employees.

In order to understand the process and make it more efficient, thus reducing the opportunity cost, the process was designed with the help of the VSDiA tool and project management literature. With VSDiA, besides representing a process that was mostly in the owner's head, it was possible to identify potential improvement points. With this tool, the non-value-added activities or unnecessary process steps become more visible and obvious, allowing the improvement opportunities identification. Using the VSDiA tool, the role of each involved stakeholder becomes clearer, allowing an accurate responsibilities assignment. The knowledge acquired in project management was fundamental in the design of the process, as it allowed to have a clearer and more organised planning, improving collaboration between the different stakeholders and also allowed to define time-schedules and goals, increasing the effectiveness of the team. In this way, VSDiA allied to project management, provided a better process knowledge and the identification of improvement opportunities, which allows the mapping of a future state with more value-added to the customer.

On the other hand, in order to facilitate the availability and the analysis of information and to increase accuracy in the control of the results of each process, a *dashboard* was developed comprising the performance indicators necessary to meet the company's needs. This has proven to bring some improvement as it optimized the time needed to perform the monthly report by 180h per year, increased the data quality used for RPP projects management and also, supported the RPP project manager in the management of project time-schedules. Then, the dashboard was also validated by the stakeholders through a survey, and it was found to be an easy-to-use tool that only includes useful information and is therefore an added value to the process. Due to the success of the dashboard and based on the feedback received from some senior managers of the RPP process, it is in their interest to apply this tool to other plants located in other countries, such as Germany, China and Malaysia, as they saw a lot of potential in this tool.

In summary, it is possible to see that this research project aimed to act in two fields, one related to the description and improvement of the existing process in the organization and the other related to the availability of a tool that allows the company to have more efficient control and reporting mechanisms. For the first field related with the product cost optimization process description, the concepts acquired from the literature of project management were fundamental, namely concepts regarding to lean project management and the functionality of the value stream design tool for indirect areas. Also, to better understand the main goal of this methodology and its framework in the product life cycle, the knowledge acquired in the scope of cost management was essential, particularly the target costing and the kaizen costing. Finally, related to the reporting tool, the business intelligence literature allowed a better planning, development and implementation of the tool. In both areas, today there is the possibility for the company to have more efficient processes and tools to help react to adverse situations.

6.2 Limitations

Throughout this research project some limitations were found that affected the work developed. Firstly, as the RPP methodology was not described, there was some difficulty in gathering all the available information in order to understand the methodology.

Then, the fact that the RPP methodology involves several stakeholders from different departments, made it difficult to find availability to schedule the workshops. Besides this, it was very complicated to estimate some values such as processing times, since there are many variables that depend from project to project.

On the other hand, since it was intended the Dashboard to update its information automatically, there was a need to connect it directly to the Masterfiles and, for this, it was necessary to have some authorizations. Besides this, with the entry of new directives, namely regarding savings calculations, the RPP methodology had to be adapted, causing some uncertainty in some important aspects. Finally, some visuals available in Power BI, are not approved by Bosch and, therefore, it was not possible to include in the dashboard all the idealized analyses.

6.3 Opportunities for future work

As future work, since process mapping is a practice that requires continuous and methodical work, the VSDiA of RPP can be reviewed in an attempt to optimize it. It would also be interesting to verify whether the process improvements reflected in a reduction of the opportunity cost, resulting in higher earnings for the company.

On the other hand, we can also work on the application of the dashboard in other plants. Besides these proposals, it would also be interesting to prove that after using these tools, the annual savings increased due to better efficiency and process management.

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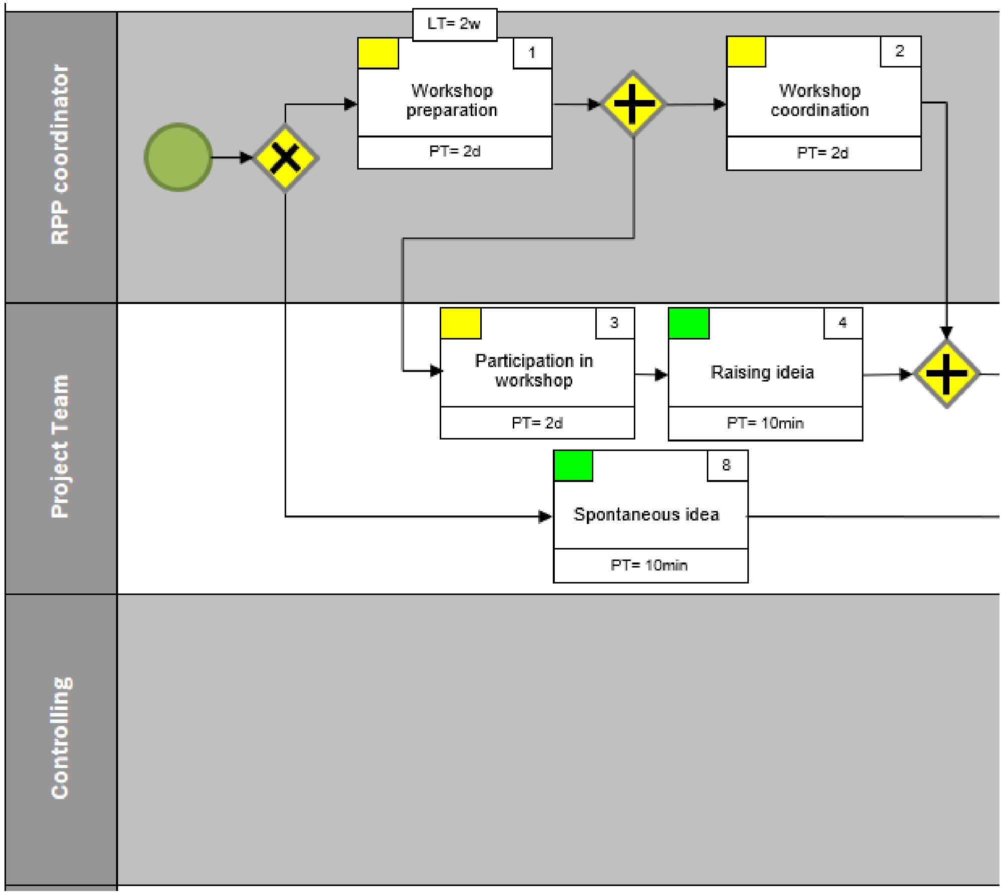
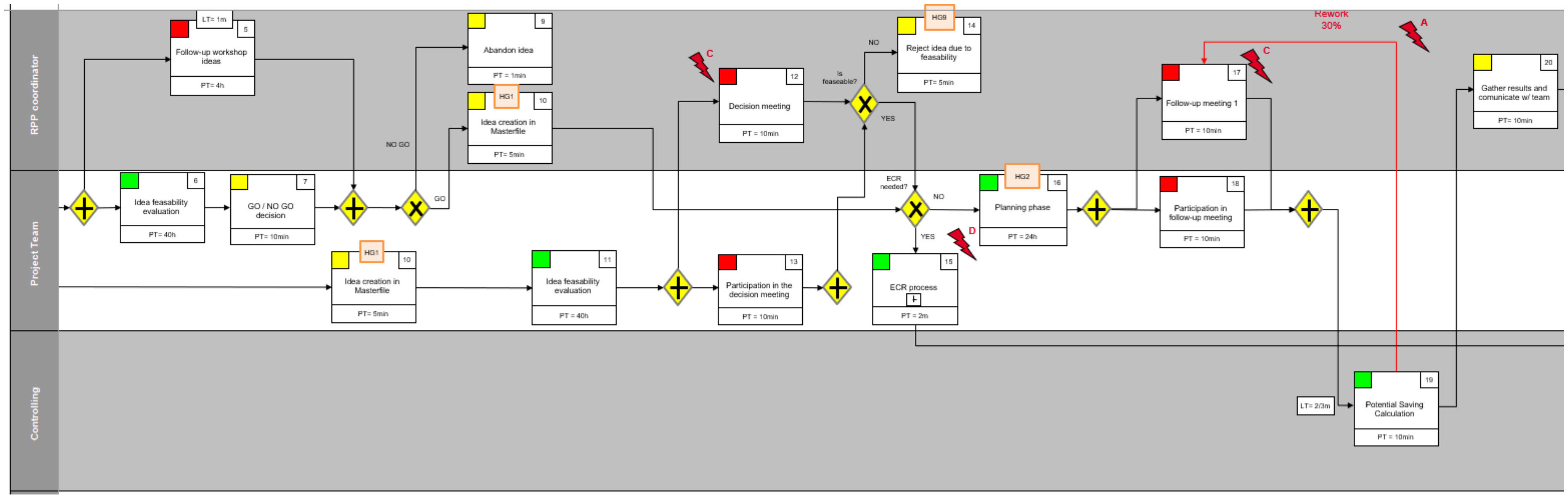
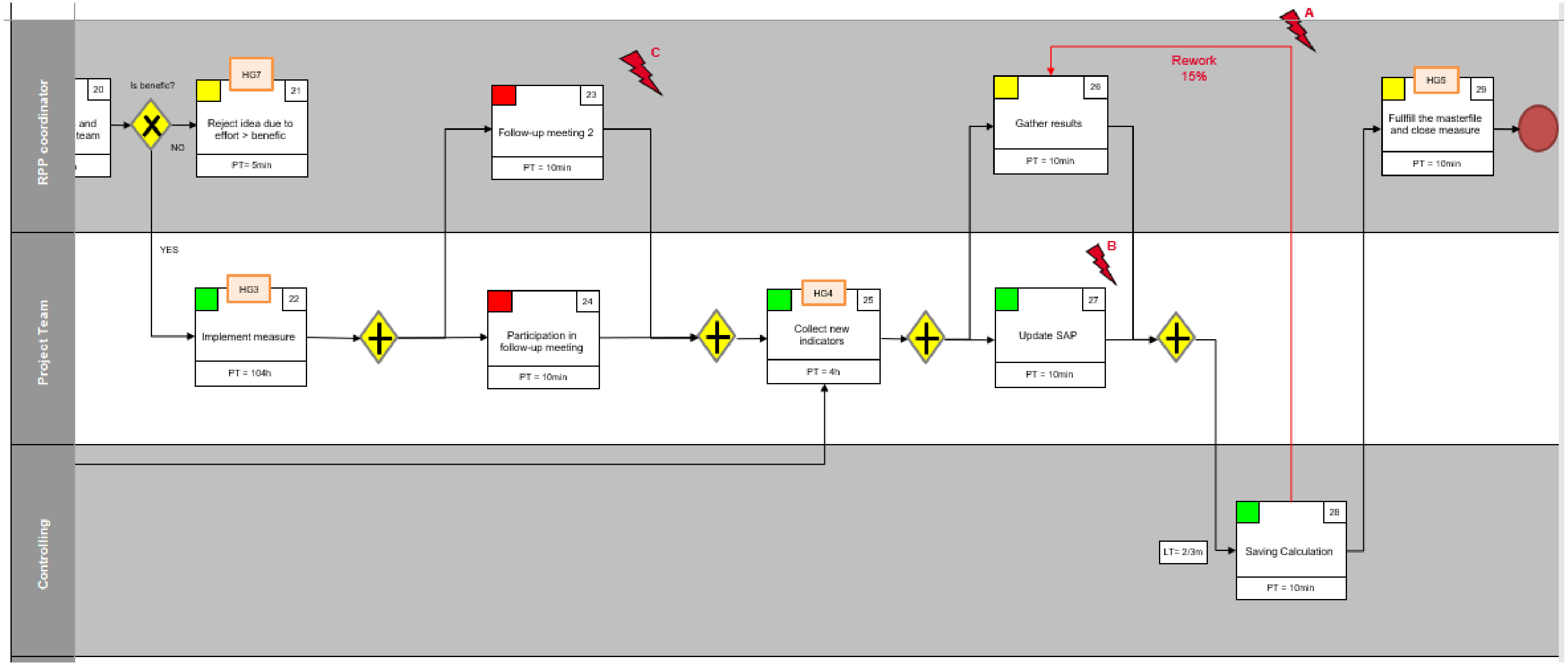
APPENDIX I – VSDIA CURRENT STATE – IDEA GENERATION PHASE



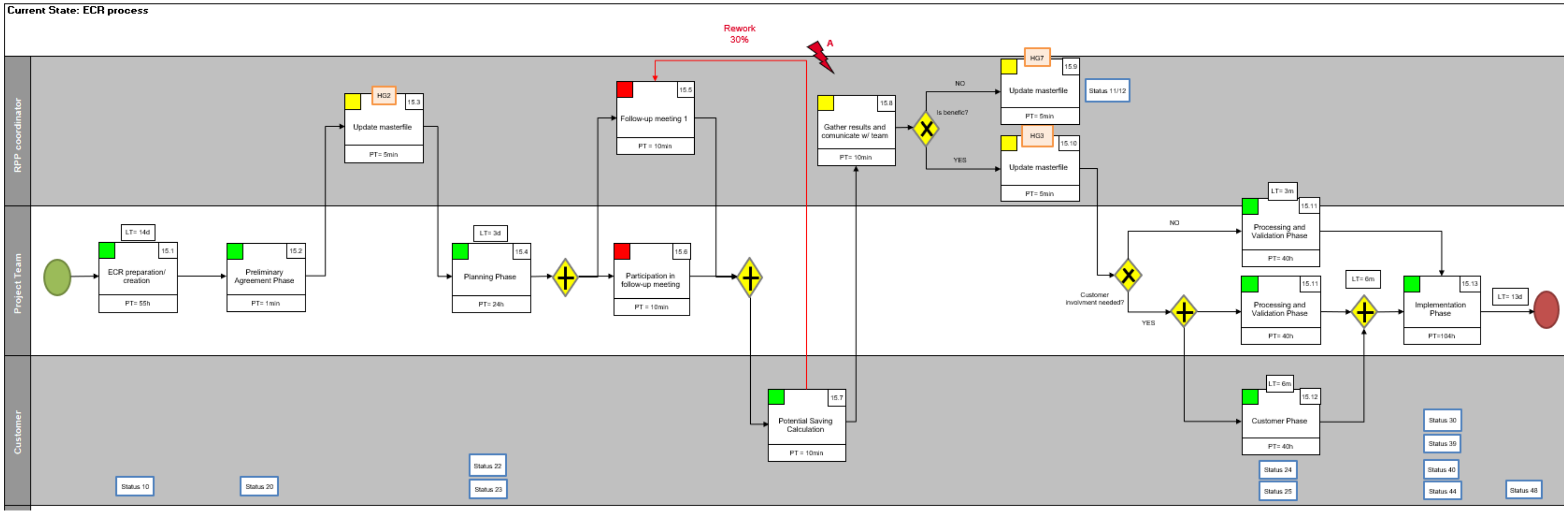
APPENDIX II – VSDIA CURRENT STATE - PREPARATION PHASE



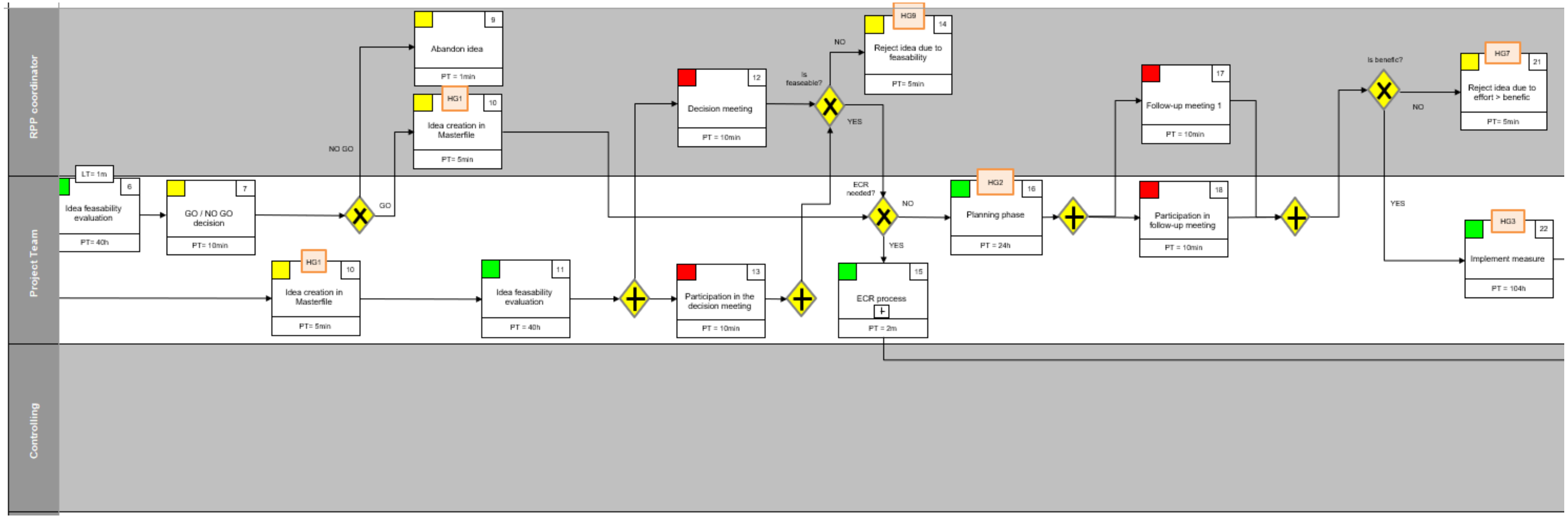
APPENDIX III – VSDIA CURRENT STATE – IMPLEMENTATION PHASE



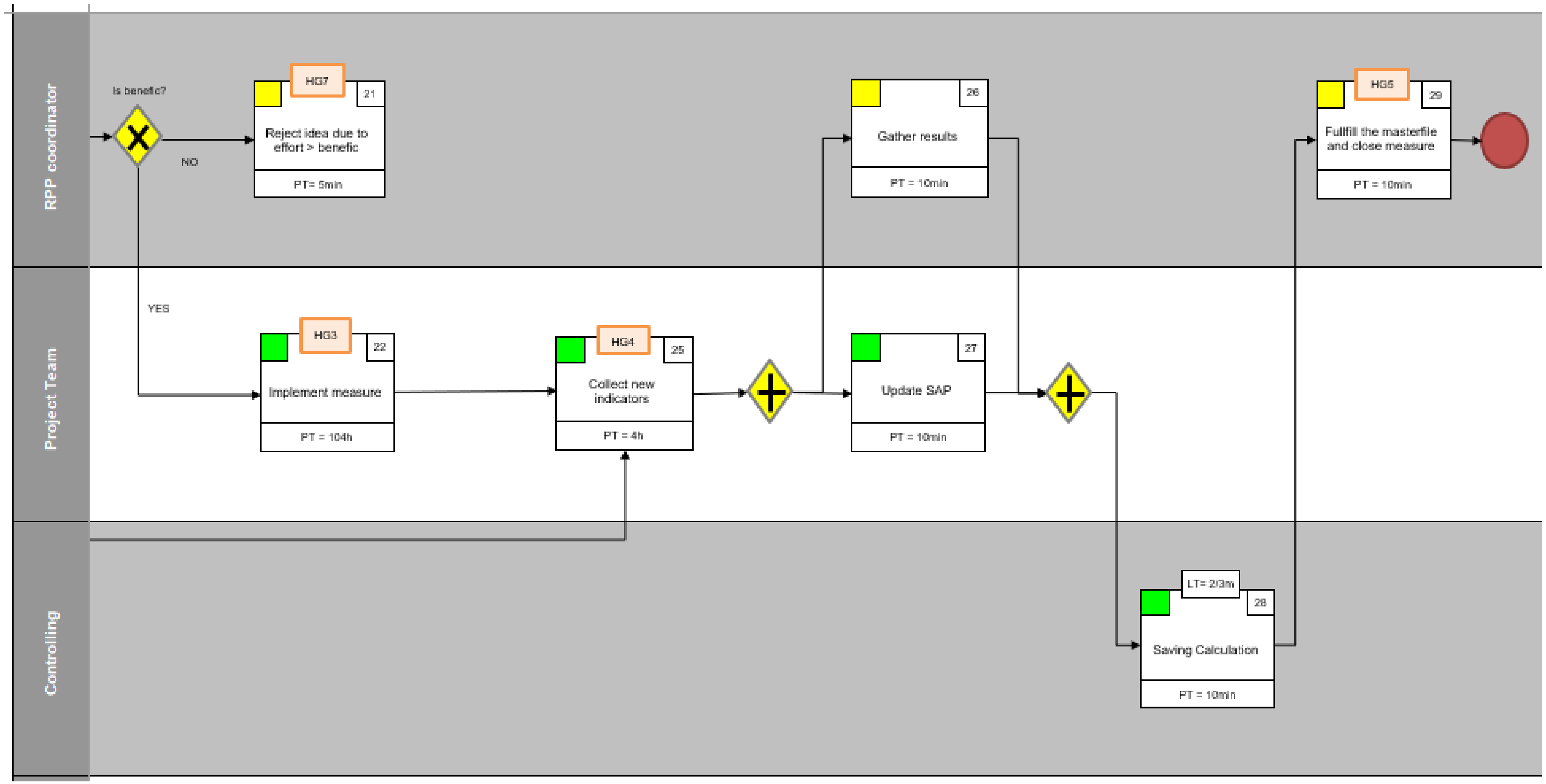
APPENDIX IV – VSDIA CURRENT STATE – ECR PROCESS



APPENDIX V – VSDIA FUTURE STATE – PREPARATION PHASE



APPENDIX VI – VSDIA FUTURE STATE – IMPLEMENTATION PHASE



Appendix VII – Survey N.01 – RPP Value Stream Mapping

UNIVERSIDADE DO MINHO
ESCOLA DE ENGENHARIA
MESTRADO INTEGRADO EM ENGENHARIA E GESTÃO INDUSTRIAL

SURVEY AS PART OF THE MASTER'S THESIS

SURVEY N.01 – RPP Value Stream Mapping

The preparation of this survey is intended exclusively to obtain data that will later be used in research. The confidentiality of your answers is completely assured.
For each of the following statements you will have 5 options of answers ordered by degree of agreement (1- I do not agree to 5- I totally agree)

1. VSDiA provides a better overview of the RPP process.

○ ○ ○ ○ ○
1 2 3 4 5

2. VSDiA enabled the identification of activities in the process that did not add value and highlighted key improvement points.

○ ○ ○ ○ ○
1 2 3 4 5

APPENDIX VIII – SURVEY N.02 – RPP DASHBOARD EVALUATION

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SURVEY AS PART OF THE MASTER'S THESIS

SURVEY N.02 - EVALUATION OF THE DASHBOARD

The preparation of this survey is intended exclusively to obtain data that will later be used in research.
The confidentiality of your answers is completely assured.
For each of the following statements you will have 5 options of answers ordered by degree of agreement (1- I do not agree to 5- I totally agree)

1. The RPP dashboard made it possible to analyse data in an easier and more efficient way.

○ ○ ○ ○ ○
1 2 3 4 5

2. The Dashboard only present useful information.

○ ○ ○ ○ ○
1 2 3 4 5

3. The Dashboard is an easy and intuitive tool to handle.

○ ○ ○ ○ ○
1 2 3 4 5