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**Development of an interface for managing  
and monitoring projects in an automotive  
company**

Master Dissertation

Integrated Master of Engineering and Industrial  
Management

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## **ABSTRACT**

In a competitive world, companies lose customers and opportunities due to lack of organisation, failure to meet dates, bad planning, among other reasons. Therefore, organisation, planning and follow-up have become essential practices for business success. Hence, project management is presented as a form to guarantee compliance with deadlines, costs reduction, sales increase, revenues growth, satisfaction of clients, among other benefits.

This master dissertation was developed in Bosch Car Multimedia, at the Centre of Competence of Printed Circuit Board, CM/MFT3 section, with the main objective to develop an interface for managing and monitoring projects. The research question was: "How can the monitoring and control of projects be improved in a section of an automotive company?".

This research question was answered through the cycles of Action Research (diagnosing, planning, taking action and evaluation). Observation of the practices used in CM/MFT3, analysis of documents and meetings with CM/MFT3 collaborators were done in order to obtain a better understanding of the problem and propose improvements. Weekly meetings were also used to follow the status of the work and adjust the proposals when necessary.

With the increasing number of projects under the supervision of CM/MFT3, the section had greater difficulties in monitoring projects' status. In order to tackle the situation, it was proposed a tool for the project status control, other for the project status overview (cockpit chart) and, simultaneously, new templates were developed for risk management, so that the project management practices could be improved.

All the established objectives were achieved during the development of this masters' dissertation and there was a significant contribution to the improvement of project management practices in CM/MFT3 section at Bosch Car Multimedia in Braga.

## **KEYWORDS**

Project Management, Cockpit Chart, Performance Measurement System, Risk Management.



## RESUMO

Num mundo competitivo, as empresas perdem clientes e oportunidades por falta de organização, falha no cumprimento de datas, mau planeamento, entre outras razões. Assim, organização, planeamento e acompanhamento tornaram-se práticas essenciais para o sucesso empresarial. Nesse sentido, a gestão de projetos é apresentada como uma forma de garantir o cumprimento dos prazos, redução de custos, aumento de vendas, crescimento de receitas, satisfação de clientes, entre outros benefícios.

Esta dissertação de mestrado foi desenvolvida na Bosch Car Multimedia, no Centro de Competência de *Printed Circuit Boards*, secção CM/MFT3, sendo o objetivo principal o desenvolvimento de uma interface para gestão e controlo de projetos. A questão da pesquisa foi: "Como melhorar o acompanhamento e o controlo de projetos numa secção de uma empresa automóvel?".

Esta pergunta de investigação foi respondida através dos ciclos de investigação-ação (diagnóstico, planeamento, ação e avaliação). De forma a compreender melhor os problemas da secção e propor melhorias recorreu-se à observação das práticas utilizadas em CM/MFT3, análise de documentos e reuniões com os colaboradores de CM/MFT3. Ao longo do decorrer do trabalho realizaram-se reuniões semanais para acompanhar o estado do trabalho e ajustar as propostas se necessário.

Com o crescente número de projetos sob supervisão de CM/MFT3, a secção tinha grandes dificuldades na monitorização do status dos projetos. A fim de resolver a situação, foi proposta uma ferramenta para o controlo do progresso dos projetos, uma ferramenta para a visão geral do *status* dos projetos (*cockpit chart*) e, simultaneamente, foram desenvolvidos novos *templates* para gestão do risco, a fim de melhorar as práticas de gestão de projetos da secção.

Todos os objetivos estabelecidos foram alcançados durante o desenvolvimento desta dissertação de mestrado e houve um contributo significativo para a melhoria das práticas de gestão de projetos na secção CM/MFT3 da Bosch Car Multimedia em Braga.

## PALAVRAS-CHAVE

Gestão de Projetos, *Cockpit Chart*, Sistema de Medição de Desempenho, Gestão do Risco.





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## **LIST OF ABBREVIATIONS**

AC	Actual Cost
BrgP	Braga, Portugal
CM	Car Multimedia
CoC	Centre of Competence
CPI	Cost Performance Index
CV	Cost Variance
EV	Earned Value
EVM	Earned Value Management
GE	GE –Geschäftseinheit / Operational Unit
IPMA	International Project Management Association
KPI	Key Performance Indicator
MAE	Machinery And Equipment
MFT	Manufacturing Technology
MOE	Manufacturing Operations Engineering
OPL	Open Point List
PCB	Printed Circuit Board
PEP	Production Engineering Process
PM	Project Management
PMBok	Project Management Body of Knowledge
PMI	Project Management Institute
PV	Planned Value
RBS	Risk Breakdown Structure
SPI	Schedule Performance Index
SV	Schedule Variance
T&R	Track&Release
TBC	Total Budgeted Cost



## **1. INTRODUCTION**

The present dissertation was developed in the Centre of Competence (CoC) of Printed Circuit Board (PCB) of Bosch Car Multimedia in Braga, denominated as CM/MFT3 section, with the title “Development of an interface for managing and monitoring projects in an automotive company”. This dissertation emerged under the scope of the Integrated Master in Industrial Engineering and Management from the University of Minho. The first chapter of this master’s dissertation is the introduction: this chapter presents the topics related with the dissertation motivation and background, objectives and, finally, a brief description of the dissertation structure.

### **1.1 Motivation and Background**

Bosch is a multinational company that is continuously growing. The evidence of this statement, is the plant located in Braga. Predominantly at CM/MFT3 section, this growth is clearly visible carrying extra difficulties on resources management, planning and organisation in general.

The perceived value of project management and the problems cited above are the main inspirations for this research. In this specific project, the main objective is to improve the project management practices in the CM/MFT3 section through the development of an interface for managing and monitoring projects. That allows a simple and fast view of the monitoring of the section projects.

Nowadays, companies face challenges such as fierce competition (Rocha & Tereso, 2008), narrow profit margins, rigorous customers and constant technological advances. This environment requires the implementation of more robust project management practices, since everything has to happen in an increasingly tight time frame, using less resources while maintaining the demanded quality.

Organisations have attempted to define their goals and objectives for short and long term and, at the same time, strategies to achieve them. In order to address this problem, project management has proved to be a powerful tool for overcoming various obstacles (Silva, Tereso, Fernandes, Loureiro, & Pinto, 2015). Project management has been considered a core competency at Bosch since 2000, the company where this master’s dissertation was developed. Internal projects, international dependencies, increased complexity, and the fact that increasingly non-product development activities are conducted as projects has led to good practices being implemented (Bosch, 2016c). These are the motivations sustaining the writing of this master’s dissertation in CM/MFT3, section of BrgP/MOE1 department.

After understanding the urgency of project management in organisations, it is important to indicate some notions about the concept of project management. As stated by Santos, Soares, and Carvalho (2012), Bosch (2016c) and Cleland and King (1988), project management can be defined as the use of knowledge, practices, skills and tools in the project activities in order to meet specific project requirements and achieve certain objectives.

According to Bosch (2016c) a project is a temporary effort undertaken to create a result, be it a product or service. It is possible to extend the concept by describing that a project is a complex activity that only occurs once, has defined objectives, and has limitations in resources and time for its execution (Tereso, 2002). The temporary character of projects shows that they have a well-defined beginning and an end. When the objectives are achieved or there is a failure to reach them, the project is terminated, that is, the end of the project. A project could also be terminated as the client, sponsor or promoter wishes (PMI, 2013).

Project management requires accurate monitoring of various checkpoints and types of data throughout the life cycle of a project. The way this data is presented is a very sensitive point and must be approached with all necessary care to make its interpretation as simple and straightforward as possible. It is therefore appropriate to set up a platform where it is possible to have an overview of ongoing projects. The project manager, team members, and all parties involved in the project should be able to see the progress of the project in a simple and straightforward manner. Easy access to all this information allows better management for the team.

In summary, project management is new for Bosch's CM/MFT3 section, increasing the necessity to improve its practices, predominantly concentrated on project planning, monitoring and controlling. With the increase in the number of projects every year - 2013 with about two projects and 2017 with more than sixteen; with the increase in projects' complexity; in the number of international projects and internal dependencies, it becomes clear that CM/MFT3 needs to improve the practices of project management in order to plan, manage and control the projects in a sustainable manner.

## **1.2 Objectives**

The CM/MFT3 section is structured into four different areas, according to the work developed.

This master dissertation was developed in Project Office and Information Management area which is responsible for the integration of all areas in order to have all the work developed in the section connected, which makes essential the collaboration and good communication of all section's collaborators even if they work in separated areas.

The present master dissertation was guided by the following research question: “How can the monitoring and control of projects be improved in a section of an automotive company?”. From the research question derived the subsequent objectives, which support the development of the work:

- Define and use Key Performance Indicators (KPIs) for project management (time, resources, cost and quality);
- Extract KPIs through the tool used by the section;
- Develop and implement a tool for the overview of the projects’ status;
- Classify/prioritise projects;
- Improve risk management practices in CM/MFT3;
- Improve Project Management (PM) practice in CM/MFT3.

### **1.3 Structure of the Dissertation**

This master’s dissertation is divided into seven chapters with the aim of logically organising and structuring the work done during the project.

Chapter 1 describes the motivation and background for this master’s dissertation, the objectives to be accomplished at the end of the work and how this dissertation is ordered.

Chapter 2 presents the literature review focused on general concepts about project management and topics related to the work done like Key Performance Indicators, Cockpit Charts, among others.

Chapter 3 describes the research methodology used to develop this master’s dissertation.

Chapter 4 presents Bosch Group and, specifically, the Car Multimedia division in Portugal (Braga). CM/MFT3 is also described since it is the section where this master dissertation was developed.

Chapter 5 reflects the actual status of CM/MFT3.

Chapter 6 presents the improvements and the results of the work developed.

Lastly, Chapter 7 addresses the main conclusions from this master’s dissertation and highlights its distinctive contributions, its limitations, as well as suggestions for future work.





**2. LITERATURE REVIEW**

Based on the objectives established in Chapter 1, a literature review directed to the topics considered relevant to this dissertation was done in order to understand the state of the art.

**2.1 Organisational Project Management**

It is important to understand how portfolio, program, and project management are related to Organisational Project Management (OPM) and how these pieces are interrelated and should be guided by and in turn support the organisation's strategic goals. This means that any change to the organisational strategy will require changes to the organisation's portfolios, programs and projects. It is also relevant to recognize the similarities and differences among these disciplines. Organisational project management, Figure 1, is a concept that links project, portfolio and program management with organisational practices and strategy in order to obtain better results, performance and a sustainable competitive advantage (PMI, 2013).

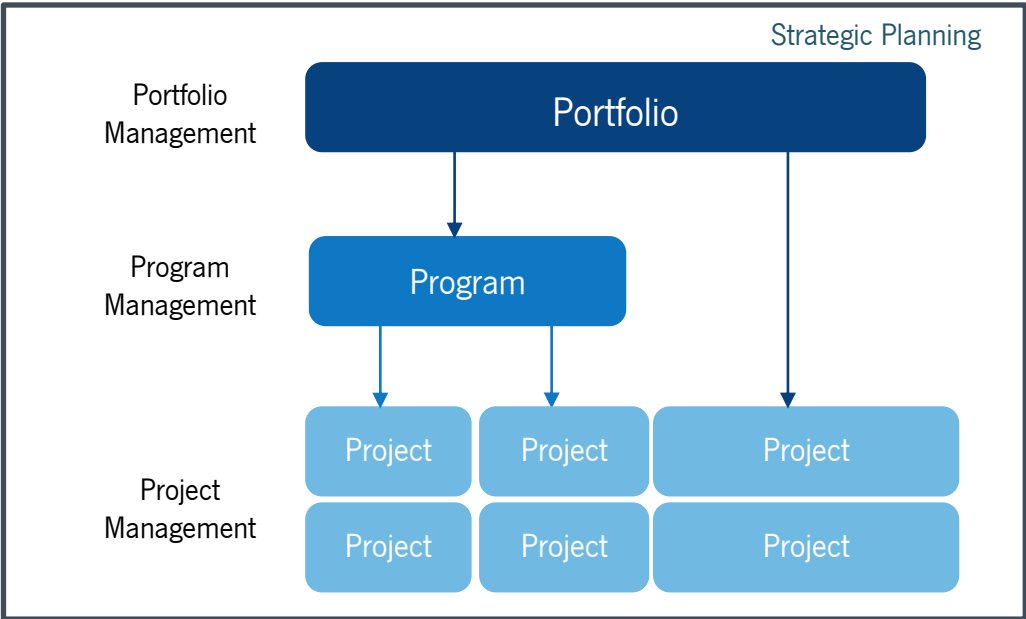


Figure 1 - Organisational Project Management.  
Source: Author's own elaboration.

The relationship between portfolios, programs and projects is evident, since a portfolio refers to a collection of projects, programs, sub-portfolios and operations managed as a group to attain strategic objectives. The programs are gathered in a portfolio and are composed of subprograms, projects or other works that are managed in a coordinated way in support of the portfolio. Individual projects are considered part of a portfolio, whether in or out of a program. Portfolio, program and project management are aligned

or guided by organisational strategies. The way each contributes to the achievement of the strategic objectives is what differs from one another (PMI, 2013).

To support the organisation’s strategic goals, OPM establish the way how portfolios, programs, projects, and other organisational work should be prioritised, managed, executed, and measured. This means that any deviations to the organisational strategy will necessitate changes to the portfolios, programs, projects, and operational work (PMI, 2013).

Table 1 shows the comparison of project, program, and portfolio views across several dimensions within an organisation.

Table 1 - Overview matching between Project, Program and Portfolio Management. (PMI, 2013).

<b>Organizational Project Management</b>			
	<b>Projects</b>	<b>Programs</b>	<b>Portfolios</b>
Scope	Projects have defined objectives. Scope is progressively elaborated throughout the project life cycle.	Programs have a larger scope and provide more significant benefits.	Portfolios have an organizational scope that changes with the strategic objectives of the organization.
Change	Project managers expect change and implement processes to keep change managed and controlled.	Program managers expect change from both inside and outside the program and are prepared to manage it.	Portfolio managers continuously monitor changes in the broader internal and external environment.
Planning	Project managers progressively elaborate high-level information into detailed plans throughout the project life cycle.	Program managers develop the overall program plan and create high-level plans to guide detailed planning at the component level.	Portfolio managers create and maintain necessary processes and communication relative to the aggregate portfolio.
Management	Project managers manage the project team to meet the project objectives.	Program managers manage the program staff and the project managers; they provide vision and overall leadership.	Portfolio managers may manage or coordinate portfolio management staff, or program and project staff that may have reporting responsibilities into the aggregate portfolio.
Success	Success is measured by product and project quality, timeliness, budget compliance, and degree of customer satisfaction.	Success is measured by the degree to which the program satisfies the needs and benefits for which it was undertaken.	Success is measured in terms of the aggregate investment performance and benefit realization of the portfolio.
Monitoring	Project managers monitor and control the work of producing the products, services, or results that the project was undertaken to produce.	Program managers monitor the progress of program components to ensure the overall goals, schedules, budget, and benefits of the program will be met.	Portfolio managers monitor strategic changes and aggregate resource allocation, performance results, and risk of the portfolio.

By observing Table 1, it is possible conclude that portfolio management contributes for organisational project management since this area comprises the selection and prioritization of programs and projects that will best achieve the organisation’s strategic goals. Program management coordinates the management of related projects to achieve specific benefits that support the strategic goals and finally

the project management manages efforts to develop strategic scope, which supports the portfolio or program management objectives and strategic goals (PMI, 2013).

### 2.1.1 Project Management

A project can be understood as an activity that is carried out only once, having well-defined goals, where resources and time are limitations for its accomplishment (Tereso, 2002).

Regardless of its size, each project is a temporary endeavour undertaken to create a product, service or result. The set of activities it involves is distinct from other projects, with different resources, times and sequencing (PMI, 2013; Rocha & Tereso, 2008).

Projects are carried out at all levels of the organisation and may involve a single person or many thousands. Their duration varies from a few days to a few years. Projects may involve one or more organisational units, and even partnerships between organisations. Projects are a way to organize activities that are not developed in an organisation's normal operating standards. As examples of projects can stand out (PMI, 2013):

- The development of new products or services;
- Changes in the structure or organisations, hiring of personnel or organisational style;
- The design of a new vehicle or means of transport;
- The development, acquisition or modification of an information system;
- The construction of a building or facility;
- Running a campaign for a political office.

Traditionally, projects are undertaken to respond to market requirements, the needs of organisations, technological advances and legal requirements (PMI, 2013).

During the life of a project, there are several stages of development (Figure 2). These stages could be defined as the project life cycle, and are common to many projects (conception, definition, planning, execution and closure). The project life cycle shows the effort needed as the project evolves, from the beginning to its completion (Jurison, 1999).

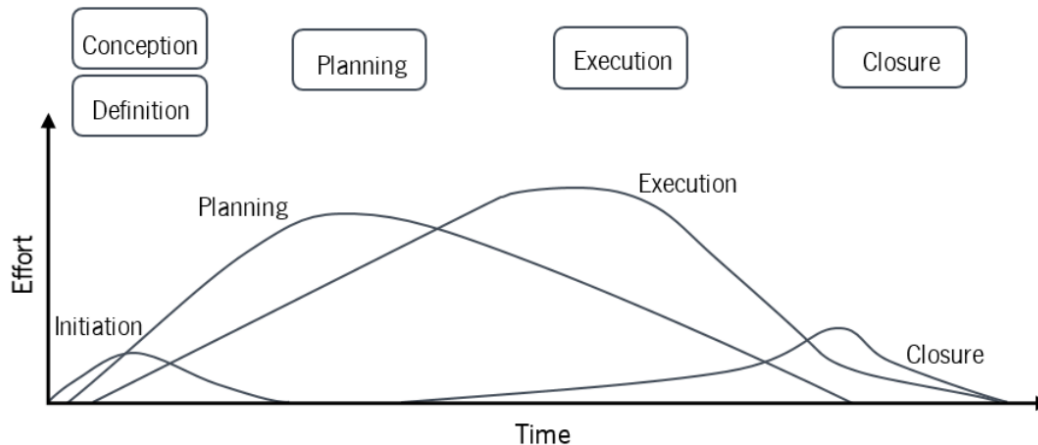


Figure 2 - Project life cycle.  
Adapted from: Gray and Larson (2006); Sandeep (2010).

The conception stage concerns the identification of an internal need or external requests. The objective may be a vague subject or idea. In the definition phase, the mission and main characteristics of the project are determined as well as the definition of the schedule and costs. It is at this stage that the alignment between the project and the company strategy is sought. The general plan is detailed in the planning phase, it is in this stage that the plan is complete to reach the objectives stipulated (resources needed, matrix of responsibilities, communication plan, risk analysis, among others). Project charter is an important planning document. It is in the project charter that agreements are transformed into a documented project management approach. The project charter provides a statement of the goal and direction of the project, as well as further information concerning the project environment (Hayes, 2000).

The execution should follow the plan. For example, there should be updates of the activity schedule, communication about project design and preparation of plans for identified deviations. One of the shorter phases is the closure. However, it is a very important phase, since it is at this stage when all the results of the project are analysed and checked whether these achieved the objectives established at the start of the project or updated during its course. It is also at this stage that the lessons learned in the course of the project are evaluated (Jurison, 1999; Klein, 2000; Meredith & Mantel, 2008).

A project aims to achieve the desired results after performing the tasks established in a given period, keeping costs within the budgeted limits (Jurison, 1999).

Verzuh (2000) considers that projects should take into account: clarity of objectives among the project's team, general responsibility plan, performance measurement indicators, constant and effective communication, controlled scope and support to project management.

Managing through projects has become a standard way of doing business and now can be distinguished to form a vital part of many organisation's strategies (Björkegren, 1999). These projects are

temporary coordination systems in which diverse, skilled specialists work together to perform complex and innovative tasks within a predetermined time (Grabher, 2002). The main features of projects are: the substantial interdependence of diverse types of knowledge and skills, the complexity and unpredictability of many tasks and problems and the time-delimited nature of project goals (Mian, Takala, & Kekäle, 2008).

The most important attribute of a project is that it must be important enough in the eyes of upper management to warrant the creation of a special organisational unit outside the organisation's routine structure. If the rest of the organisation feel, or even suspect, that is not really important, the project is usually doomed to failure. The symptoms of lack of importance are numerous and subtle: there is no mention of it by upper management, handover the project to someone with a lower position, adding the project responsibilities to someone who is already too overloaded and not monitoring its progress (Meredith & Mantel, 2008).

There is a rapid increase in the number of companies that adopt project management practices to accomplish specific goals. Not even the most optimistic analysts predicted the explosive growth that took place in the field (Meredith & Mantel, 2008).

In Figure 3, the project objectives are specified in the axes (Performance, Cost, Time). This illustration implies that there is some “function” that relates them to one another, although the functions vary from project to project, and from time to time in a particular project (Meredith & Mantel, 2008).

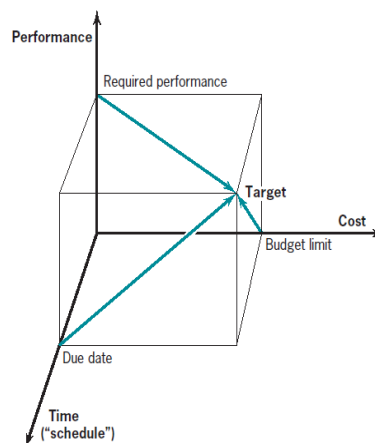


Figure 3 - Direct project goals - performance, cost, time. (Meredith & Mantel, 2008).

Therefore, there are three critical variables in a project, namely, the expected time, costs, and performance, which require the full attention of a project manager. In this way, its main objective is to find an optimal point that is a balance between these variables (minimum cost and duration, and maximum performance) that does not compromise each other. A proper management of a project usually results in success (Jurison, 1999).

However, critical success factors change according to project characteristics. The expected results, for example, in projects developed in private organisations, where the profit target is relevant, may not be similar to the projects implemented in those non-profit organisations (C. Santos, Santos, Tavares, & Varajão, 2014).

Several authors recognise that project management can be understood *“as the application of knowledge, skills, behaviours, tools, and techniques to project activities to meet specific project requirements”* (Cleland & King, 1988; Mohammadi & Khalili, 2008; PMI, 2013).

It is also performed through the application and integration of different tasks like initiation, planning, execution, monitoring and control and conclusion (Mohammadi & Khalili, 2008; PMI, 2013; Sommerville, 2004). Project management is a process that aims to achieve the objectives set by the limited time and resources available (human, machines, materials), in order to minimize the total costs of the project, maintaining (or even improving) the quality of the implementation of the work and its end result (Roldão, 2000; Sommerville, 2004; Valerdi & Davidz, 2008).

The project manager has the responsibility to the accomplishment of project goals. Managing a project includes (PMI, 2013):

- Identify project requirements;
- Establish objectives in a clear and viable way;
- Balance the quality, scope, time and cost;
- Adapt the specifications, plans and address the different concerns and expectations of the various stakeholders.

Project managers also manage projects in response to uncertainties (PMI, 2013).

### 2.1.2 Program Management

In the past, the Egyptians would have identified the magnitude of a program, since they perceived the advantages that was possible to have through handling varied projects and supporting non-project work together as a program (Levin, 2012).

A program is a group of connected projects, subprograms, and program activities coordinated simultaneously in order to obtain benefits, which it is not possible to obtain by managing themselves apart. A program will always have projects but a project may or may not be part of a program. Projects within a program are related through the mutual outcome or collective capability (PMI, 2013).

A program comprises a set of related projects and required organisational changes to achieve a strategic goal and to reach the defined business benefits. The change character is appearing, as many organisational change initiatives are successfully introduced as programs (Levin, 2012).

Programs establish the missing link between the executive level policy, the projects and the operations that will enable it to deliver value (Thiry, 2012).

Program durations may not always be identified at the outset. However, a program can and will eventually reach the end of its useful life cycle. At that point, as a strategic business decision, the program should be terminated (Levin, 2012).

Many times, a program is not distinguishable from a project, but frequently meant to cover a group of similar projects oriented towards a particular goal (Meredith & Mantel, 2008).

For instance, Turner (1999) and Poskela et al. (2001) highlight that projects, which are inside of a program, are a consistent group that is managed in a synchronised way into added value. Murray-Webster and Thiry (2000) describe a program as a set of projects and operational activities clustered to accomplish strategic and/or tactical advantages.

In addition to the basic characteristics of single projects, program durations have a tendency to be longer, and thus uncertainty is higher because they may confront substantial environmental changes (Ohara, 2005).

Apollo Project is a case of a majestic program. This program got the man's first round trip to the moon and was promoted by the former President of United States, Kennedy. A great number of projects, such as the development of the rocket, training of astronauts, control of space flight and flight monitoring, were placed under integrated control. This program was very successful (Ohara, 2005).

Program management, as defined by the PMI, is the centralized coordinated management of a program. Program management is the application of knowledge, skills, tools, and techniques to a program in order to meet the program requirements and to obtain benefits and control not available by managing projects individually. It involves aligning multiple projects to achieve the program goals and allows for optimized or integrated cost, schedule, and effort (PMI, 2013). "*Examples of advantages could be increased profits, improved operations, or growth*" (Levin, 2012, p. 3).

Program Management has emerged as a discipline in the late 20<sup>th</sup> Century. It gradually developed as project management was applied to more and more complex projects, to the management of strategic objectives or the management of multiple interrelated endeavours to produce strategic benefits. Program management deals with both high ambiguity and uncertainty and requires a high degree of organisation

maturity. Program management concerns the harmonized management of a number of projects and other actions that will produce a competitive advantage (Thiry, 2012).

Program management provides a framework of capability for an organisation to flexibly adapt to changes in the external environment, by planning ways to handle with such changes (Ohara, 2005).

The program management mainly focus is business results, it is quite strategic which supports the matching with portfolio management (Levin, 2012).

Program management emphasizes the interdependencies of projects and supports the decision of an optimal approach for management these projects. Actions related to these interdependencies may comprise (PMI, 2013):

- Solving resource constraints and/or conflicts that disturb multiple projects within the program;
- Aligning organisational/strategic course that affects project and program goals and objectives;
- Resolving issues and scope, cost, schedule, and quality changes within a shared governance structure.

Program manager is the person who is classically responsible for a number of connected projects, each with its own project manager (Meredith & Mantel, 2008).

### 2.1.3 Portfolio Management

According to PMI (2013), a portfolio refers to projects, programs, sub portfolios, and operations managed as a group to reach strategic objectives. The projects or programs of the portfolio may not necessarily be interdependent or directly related.

To achieve companies' goals, organisations implement portfolio management practices and tools, which consists in a centralised management of one or more portfolios. Portfolio management focuses on ensuring that projects and programs are reviewed to prioritise resource allocation, and that the management of the portfolio is consistent with and aligned to organisational strategies (PMI, 2013).

Portfolio management guarantees that an organisation can leverage its project selection and execution success. Portfolio management is a way to bridge the gap between strategy and implementation (PMI, 2013).

In a project-based environment, the corporate strategy delineates the high level overview and identifies the corporate goals; the integration to the corporate strategy is sustained by portfolio management (Thiry, 2012).

Benefits are combined deliverables that leverage against each other, and together provide a larger gain to the organisation than just the simple sum of those deliverables (Levin, 2012).



Archer and Ghasemzadeh (1998) define a project portfolio as a group of projects that are led under the sponsorship or management of a particular organisation. The authors point out that these projects compete for scarce resources. The three recognized aims of portfolio management are the following (Cooper, Edgett, & Kleinschmidt, 2001):

- Maximizing the value of the portfolio for a given resource expenditure, and so various financial models, risk and probability models and a scoring model approach are presented as ways to realise this goal;
- Connecting the portfolio to the strategy. Bottom up approaches - where accurate selection of individual projects results in a strategic portfolio - and top down method, such as strategic buckets, where the business's strategy drives the portfolio, are used;
- Balancing the portfolio – the right mix of projects. Here the emphasis is on visuals and graphics (bubble diagrams and more traditional charts), which reveal the spending breakdowns in the portfolio.

The portfolio management strategy is to maintain corporate identity and to ensure linkages between projects. Simultaneously, strategy helps to constrain the impact of individual projects, without connection with other projects (Lundin & Stablein, 2000). According to Platje et al. (1994) a portfolio consists in the collection of projects that when managed simultaneously bring benefits and profits that would not exist if these projects were managed individually.

Portfolio management began to catch the attention of project managers in the 1990s. They argued that portfolio planning analysis would grow in that decade and become a key tool for the future (Cooper et al., 2001).

Portfolio Management helps select, prioritise, and support the right projects to achieve the organisation's strategic intentions, helping to allocate human and financial resources to the various projects that are active, managing priorities through the rank of each project (Lourenço, 2014).

Through the management of portfolios, different projects are controlled and modified over time, in order to improve their effectiveness and efficiency, allowing the achievement of more with fewer resources. Then the resources are distributed by the different projects in order to optimize and avoid wastage of costs. This whole decision-making process is made by the portfolio manager, who is responsible for the synchronisation of diverse projects that are taking place at the same time (Cooper, Edgett, & Kleinschmidt, 1997, 1999; Cooper et al., 2001; Cooper, Edgett, & Kleinschmidt, 2002b; Durand, 2005).

Portfolio management is directly linked to the management of programs and projects, although it has dissimilar objectives. According to Schelini and Martens (2012), the portfolio management process has uncertainty and lack of information, project dynamism, interdependence between projects and organisational barriers.

Some authors have defined portfolio management as vital to business success in organisations because:

- It links the particular project and the business plan (Cooper & Edgett, 2003; Cooper et al., 1997, 2001, 2002b; Cooper & Kleinschmidt, 2007; PMI, 2013; Rad & Levin, 2006);
- It balances small and long-term, low and high-risk projects that are consistent with the organisation's business objectives (T. A. Castro, 2010; Cooper et al., 2001, 2002b);
- Increases transparency of costs, risks and benefits (Bonham, 2004; T. A. Castro, 2010);
- Identifies and corrects performance problems (T. A. Castro, 2010);
- Reduces unplanned uncertainties and events (T. A. Castro, 2010);
- It provides an overview of the organisation's projects (Rad & Levin, 2006).

## **2.2 Project Management Evolution**

The use of projects and project management continues to grow in society and organisations. Although project management has existed before the days of the great pyramids, it has enjoyed a surge in popularity since the early 1960s. A project took the American astronaut Neil Armstrong to the moon. A project baptised “Desert Storm” liberated the nation of Kuwait. The use of project management to realise the many and diverse goals of organisations and society continues to grow (Levin, 2012; PMI, 2016).

As project management techniques have been developed, mainly by the military, the use of the project management in civil organisations began to be spread. Private construction companies have discovered that the organisation by projects was useful in smaller projects, like the construction of a warehouse or an apartment complex. Automotive companies have used the organisation by projects to develop new car models. Project management has been used even to develop new models of ships. More recently, the use of project management by international organisations, and especially organisations producing services instead of products, has grown rapidly (Levin, 2012).

While some argue that the construction of the Babel Tower or the Egyptian pyramids were some of the earliest “projects”, it is likely that cavemen have devised a project to gather the raw material for mammoth stew (Levin, 2012). It is certainly true that the construction of the Boulder Dam and the

invention of the lamp by Edison were projects by any reasonable definition. It was said that it was in the Manhattan project that begun the modern project management. In the beginning, project management was used for research and development projects (R&D), such as the execution of the Atlas Intercontinental ballistic missile and common military weapon systems. Construction of dams, ships, refineries, motorways, among others, were also organised as projects (Levin, 2012).

Project management has evolved from a non-structured, non-recognized practice to one whose impact can be felt in almost every field of endeavour (Ohara, 2005).

In order to illustrate the evolution of project management, a timeline was created with the most important moments in history of project management (Figure 4).

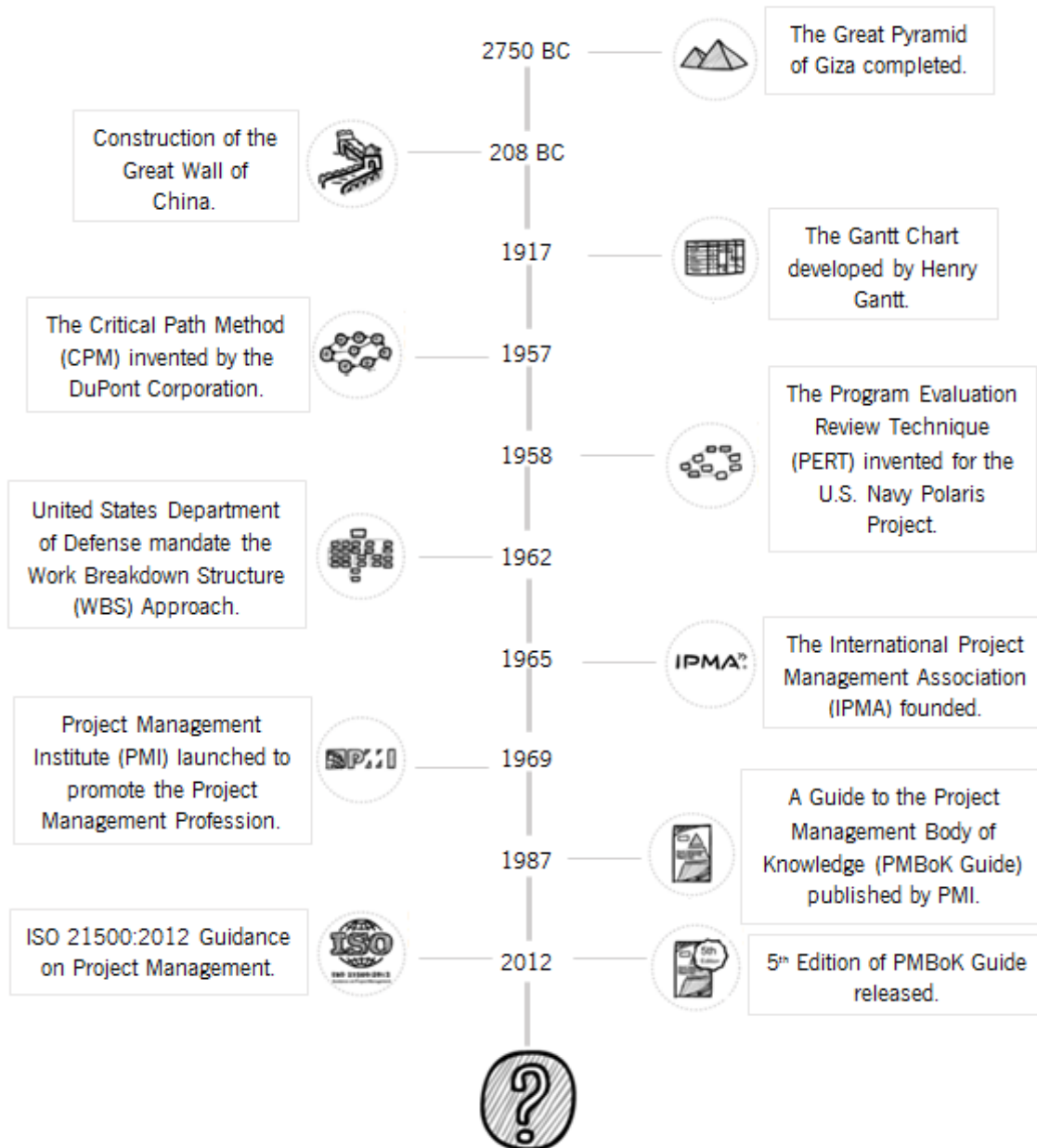


Figure 4 - Project management evolution.  
Adapted from: Haughley (2010).

According to Boyer (2017), Haughley (2010), and Ohara (2005) the greatest achievements in project management are:

- 2570 BC: The Great Pyramid of Giza Completed

Projects are as old as the Great Pyramids of Egypt (4500 years ago), perhaps even older than the pyramids. The pharaohs have built the pyramids and even today archaeologists cannot see how such a scale was possible. Ancient records show that there were managers for each of the four faces of the Great Pyramid, responsible for overseeing its conclusion. Already at that time, there was some degree of planning, execution and control involved in the management of this project.

- 208 BC: Construction of the Great Wall of China

Later still, another wonder of the World was built - the Great Wall was a large project. According to historical data, the labour force was organised into three groups: soldiers, common people and criminals.

- 1917: The Gantt-Chart developed by Henry Gantt (1861-1919)

Henry Gantt developed the popular Gantt-Chart, a scheduling instrument that has proven beneficial for tracking project progress. One of its first uses was on the Hoover Dam project started in 1931. Gantt-Charts are still in use and form an important part of the project managers' toolkit.

- 1957: The Critical Path Method (CPM) invented by the DuPont Corporation

CPM is a technique, industrialised by DuPont, used to predict project duration by examining which order of activities has the least amount of scheduling flexibility. The technique was so successful it saved the corporation \$1 million in the first year of its implementation.

- 1958: The Program Evaluation Review Technique (PERT) invented for the U.S. Navy's Polaris Project

The United States Department of Defence developed PERT. This method is used to analysing the tasks involved in completing a project, especially the time needed to complete each task and identifying the minimum time needed to complete the total project. This technique allowed the military to determine how long it would take to complete a task as well as the earliest possible time to complete a project.

- 1962: United States Department of Defence created the Work Breakdown Structure (WBS) Approach

The United States Department of Defence created the WBS concept. Work Breakdown Structure is a complete, hierarchical tree structure of deliverables and tasks that need to be performed to complete a project. The WBS remains one of the most common and convenient project management tools.

- 1965: The International Project Management Association (IPMA) is founded

For the purposes of networking and exchange of information relevant to project management, a group of project managers in Switzerland came together in 1965 to create the International Project Management Association (IPMA). IPMA was the World's first project management association; its vision is to endorse project management and to lead the expansion of the profession.

- 1969: Project Management Institute (PMI) launched to Promote the Project Management Profession

Five volunteers founded PMI as a non-profit professional organisation devoted to advance the practice, science and profession of project management. The PMI has become known as the publisher

of “A Guide to the Project Management Body of Knowledge (PMBoK)” considered one of the indispensable tools in the project management profession nowadays.

- 1987: A Guide to the Project Management Body of Knowledge (PMBoK Guide) is published by PMI

The PMBoK Guide was an endeavour to document and homogenise project management information and practices. The guide is one of the essential tools in the project management profession today and has become the global standard for the industry.

- 2012: ISO 21500:2012 Standard for Project Management is released

In September 2012, the International Organisation for Standardisation (ISO) published “ISO 21500:2012, Guidance on Project Management”. The standard is planned for use by any organisation, including public, private or community groups, and for any project, indifferent of complexity, size and duration.

- 2012: 5th Edition of PMBoK Guide is released

The fifth edition of the guide provides guidelines, rules and characteristics for project management renowned as good practice in the career.

Project management has a long history and has been capable of delivering large scale projects. From the great pyramids to modern buildings, project management is continually improving and creating new techniques. The last few decades presented new ways of approaching project management and the future will bring about new ways of thinking. The world is shifting, and project management will need to change with it (Boyer, 2017; Haughey, 2010; Ohara, 2005).

### **2.3 Knowledge Areas in Project Management**

A Guide to the Project Management Body of Knowledge (PMBoK Guide) is the distinguished global standard for project management. It offers project professionals with the fundamental practices needed to achieve organisational results and excellence in the practice of project management. It is the entire collection of processes, best practices, terminologies, and guidelines that are accepted as standards within the project management industry (PMI, 2013).

PMBoK is divided in ten knowledge areas which are very important to project management. The ten areas are (PMI, 2013):

- Project Integration Management

Includes all processes and activities required to identify, define, combine, unify, and synchronise different processes and project management activities inside the project management process groups.

Integration management requires that choices be made about resource allocation, compromises between conflicting objectives and alternatives, in addition to the management of mutual dependencies between knowledge areas and processes.

- Project Scope Management

Includes the processes required to guarantee that the project includes all and only the work necessary to complete the project with success. The focus is the definition and control of what is and what is not within the scope of the project.

- Project Time Management

Includes the processes required to manage project to finish in time. This area includes processes needed to estimate tasks, their durations and resources in order to manage the project to its completion on time. In small-scale projects, the processes of defining and sequencing activities, estimating durations and resources, and developing timelines are often seen as a single process.

- Project Cost Management

Includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs in order to make the project finish within the approved budget.

- Project Quality Management

Includes the processes and activities of the organisation that determine the quality strategies, goals, and responsibilities for the project to satisfy the needs for which it was undertaken. The implementation of the quality management system and activities is essential for the continuous improvement of the processes.

- Project Human Resource Management

This field of knowledge contains the processes that bring together, manage, and lead the project team. It is part of this area of knowledge to describe the personnel needs and their respective skills and abilities. Involving the team from the initial phases of the project adds knowledge and strengthens the commitment. The project team is a collection of people with roles and responsibilities assigned to complete the project. Project team elements can have a set of varied competencies, with full or partial allocation, and can be added or removed from the team over the course of the project.

- Project Communications Management

Includes the processes that are required to ensure timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and the ultimate disposition of project information. Effective communication helps with the involvement of all stakeholders.

- Project Risk Management

Includes the processes of conducting risk management are: planning, identification, analysis, response planning, and controlling risk on a project. Risk management aims to increase the likelihood and the impact of positive events and reduce the probability and the impact of negative events in the project.

- Project Procurement Management

Includes the processes necessary to purchase products, services, or results needed from outside the project team. Processes in this area include procurement planning, solicitation planning, solicitation, source selection, contract administration, and contract closeout.

- Project Stakeholder Management

Includes the processes required to identify all people or organisations impacted by the project, analysing stakeholder expectations and impact on the project, and developing appropriate management strategies for effectively engaging stakeholders in project decisions and execution. The objectives of stakeholder management are based on increasing the support and commitment of the stakeholders to the project, using strategies to identify and manage stakeholder expectations.

## **2.4 Project Risk Management**

Project risk management is an area of great interest for organisations. Risk management can offer a systematic process that aims to identify and manage risk in order to act if it arises, contributing to define different project objectives, improve project control, enhance the odds of project success, improve communication between project participants, facilitate decision-making and prioritise actions (Marcelino-Sádaba, Pérez-Ezcurdia, Echeverría Lazcano, & Villanueva, 2014).

The term risk is defined in PMBoK, as an undefined event or condition that, if happens, has a positive or negative effect on a project objective (PMI, 2013). According to Simon, Hillson, and Newland (1997) the meaning of risk is not different, the authors considers that risk is an indeterminate event or set of circumstances that, if they occur, will have an effect on the achievement of the project's objectives.

According to Cervone (2006), risk is a problem that has not happened – yet. While this might be a bit naive, it does get to the central of the issue a project manager faces: “What are the problems I might encounter while performing this project and how do I avoid them?” Given the critical nature of this query, one might think that risk management would be high on every project manager's agenda.



Definitions of risk always include positive (welcome) and negative (unwelcome) effects. The risk, generally, is considered as only causing negative effects (threat) by most managers (Ward & Chapman, 2003).

According to Cervone (2006) risk mitigation strategies can be:

- Reduce or eliminate by including problem correction activities into the project plan;
- Transfer responsibility for risk to a third party;
- Absorb or pool by simply planning for them;
- Avoid using quality control procedures and practices.

Risk management guarantees that practically all problems are discovered early enough so that there is time to recover from them without missing schedules or overspending the budget (Tamak & Bindal, 2013). Leung, Chua and Tummala (1998) contend that formal risk management approaches can offer a useful vision into the project and provide more information to increase the quality of investment decisions.

Elkington and Smallman (2001) claim that project risk management is vital for the project's success. The authors have identified that the most successful projects undertook more risk management practices. They also perceived that the earlier risk management is initiated, the more successful a project is. These deductions were found from a questionnaire that the authors prepared to project managers.

As Keil et al. (1998) observed, the most common risk factors among projects are:

- Lack of senior management commitment to the project;
- Failure to obtain user commitment;
- Misunderstanding of the requirements;
- Lack of adequate user involvement;
- Failure to manage end user prospects.

One point that is particularly interesting here is the use of “commitment” rather than “support”. Keil et al. (1998) point out that a project monetarily is much simpler than actively working on it in the long run. For project managers, it is the ultimate type of support that is vital.

#### 2.4.1 Risk Management Process

A risk management methodology normally enables risks identification, qualitative and quantitative assessment, response planning and monitoring. Thus, the project manager has available a set of tools and techniques which allow to increase the probability and impact of events that may appear as

opportunities for the project and decrease the probability and impact of the ones that may cause negative effects on the project objectives (PMI, 2009, 2013).

PMBok defines six risk management processes (Figure 5).



Figure 5 - Stages of risk management.  
Adapted from: (PMI, 2013).

Risk management plan

The risk management plan establishes all the activities that the project management team need to handle to manage the risks and uncertainties of the project.

The main output of the risk management plan is the risk register. It collects all the information about the identified risks, qualitative and quantitative evaluation, risk response and status during the risk monitoring and control. Risk management is an iterative and continuous process (Fernandes, Ward, & Araújo, 2013), and the risk register must be regularly updated in order to identify new risks and control others that may occur (PMI, 2009).

Risks Identification

The risk identification allows identifying and documenting risks that may affect the project objectives.

Along with this activity, the risk qualitative analysis is also performed, as well as the identification of risk potential responses, in order to provide a better understanding of the risks that were identified.

Brainstorming is typically used in order to improve the process of identifying risks and their consequences. The decision tree analysis is also recommended, since this tool facilitates the process of

thinking about the decisions and consequences that can occur due to a risk, and eventually helps to find some potential secondary risks. The Risk Breakdown Structure (RBS) organizes the risks identified by their classification in terms of types of sources. All the information collected must be filled up on the project risk register (Peixoto, Tereso, Fernandes, & Almeida, 2014).

#### Qualitative risk analysis

The qualitative analysis evaluates the possible consequences of the risks as well as their likelihood of occurrence, in subjective terms, in order to prioritise the risk.

As noted before, qualitative analysis is accomplished in parallel with the identification of the risks. In qualitative risk analysis the probability versus impact matrix (P x I matrix) is recommended (Peixoto et al., 2014).

#### Quantitative risk analysis

The risk management plan specifies that the quantitative analysis is not required for all project risks identified. The quantitative analysis is suggested to be led for the most important project risks, considering their probability and impact resultant from the qualitative analysis (Peixoto et al., 2014).

#### Plan risks response

A risk response plan should be identified for all risks, even if the response is within acceptable levels, or in other words there is no action to mitigate the risk. The risk response planning helps to develop actions to enhance opportunities and to reduce threats in project objectives (Kutsch & Hall, 2010; PMI, 2013).

#### Risk monitoring and control

Monitoring and controlling risks enables the project manager to keep track of the defined risks and identify new risks during the project and during the implementation of the risk response plans (Kutsch & Hall, 2010; PMI, 2009, 2013).

All lessons learned must be collected in a single file to ease the access to the information, in order to avoid the same mistakes or misjudgements all over again during the project risk management process, and to provide know-how for future projects (Peixoto et al., 2014).

Project risk management is an essential part of project management, that manages the uncertainties and known risks of the project and, as a result, delivers information that may be used to optimize the decision-making process (Peixoto et al., 2014).

2.4.2 Risk Management Tools and Techniques

Project risk management is a key phase of project management. Risk management is the identification, evaluation, and prioritisation of risks tracked by harmonised and economical application of resources to reduce, monitor, and control the probability and/or impact of unfortunate events or to maximize the realisation of opportunities (PMI, 2013).

The use of tools and techniques to support project risk management is essential. The correct choice of tools and techniques will help reduce the complexity of risk management.

Raz and Michael (2001) carried out a study to determine which tools and techniques are most commonly used by project managers during project risk management. In this study the tools were grouped in five stages like it is defended by the Software Engineering Institute Risk Management process (Dorofee et al., 1996):

- Identification: process of converting issues into risks that can be defined and measured;
- Analysis: on this process the risks identified before are evaluated, classified and prioritised;
- Planning: on this process it is decided what must be done with a risk, the action plans for the risks should be defined;
- Tracking: the process of gather, timely, and pertinent risk data and present it in a clear and easily-understood way to the person/group who gets the status report;
- Control: the objective of this process is to make informed, successful and timely choices about risks and their mitigation plans.

The authors, Raz and Michael (2001), added a new group to what they called “Background”. On this group the tools, processes and practices of a general nature are represented. The tools in this group affect the way in which risks are handled without being exactly correlated to one of the five stages.

The ten tools that received the highest mean score are presented in Table 2 (Raz & Michael, 2001).

Table 2 - Project Risk Management Tools.  
(Raz & Michael, 2001).

Rank Position	Tool/Technique	Description	Group
1	Simulation	Typical techniques for risk resolution (risk items are eliminated or resolved) include simulations, prototypes, benchmarks, among others. Full risk-analysis efforts involving simulation and prototyping normally provide better probability and loss estimations, but they may be more time-consuming and expensive (Boehm, 1991).	Background

2	Responsibility Assignment	A responsibility matrix is used to express who in the organisation is responsible for individual work elements and deliverables (Dorofee et al., 1996).	Planning
3	Risk Impact Assessment	In risk impact assessment it is evaluated the probability and the impact (consequence) of the risks identified before in risk identification (Boehm, 1991; Sisti & Sujoe, 1994).	Analysis
4	Configuration Control	The main purpose of Software Configuration Management is to establish and keep the integrity of the products of the software project during the project's software life cycle (Paulk, Curtis, Chrissis, & Weber, 1993).	Background
5	Subcontractor Management	Subcontractor management combines the concerns of Requirements Management, Software Project Planning, and Software Project Tracking. The intent of Software Subcontract Management is to select capable software subcontractors and manage them successfully (Paulk et al., 1993).	Background
6	Critical risk reporting to senior management	Top management needs to understand project risks and support disclosure to both internal and external decision-makers without causing excessive alarm or increasing reporting and compliance risks (Dorofee et al., 1996).	Tracking
7	Prototyping	Prototyping is a usual technique for risk resolution. Full risk-analysis involving prototyping normally provide better probability and loss estimations, but they may be more time-consuming and expensive. A prototype of representative safety features is the most cost-effective way to determine and reduce their effects on system performance (Boehm, 1991).	Background
8	Brainstorming	Brainstorming is a technique for exploring the potential of a group's ideas in a creative way and for the purpose of solving specific problems (Lumsdaine & Lumsdaine, 1990).	Identification
9	Time-limited action-item lists	Action item lists are a simple type of mitigation plan, simple list of actions, responsibility, and due dates for completing the actions associated with a mitigation strategy. Requires minimal documentation. Status is tracked and reported as part of the action item list (Dorofee et al., 1996).	Planning
10	Requirements Management	The purpose of Requirements Management is to be found a common understanding among the customer	Background

		<p>and the software project of the customer's requirements that will be addressed by the software project.</p> <p>This agreement with the customer is vital since it is the basis for planning and managing the software project (Paulk et al., 1993).</p>	
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By analysing Table 2 it was noted that five of the ten top techniques/tools belong to “Background” group. Also, it was concluded that risk management is closely linked to other management practices such as requirements management, subcontractor management and configuration control (Raz & Michael, 2001).

As a conclusion, the authors found that project managers attached low importance to risk control tools, considering that these tools contribute little to the project success. The cause for this depreciation could be related to the management culture, this is, project managers are willing to invest time and effort in the phases prior to risk management and with the evolution of the project managers become more occupied and are subject to resource constraints and time pressures, consequently neglecting the risk control phase, using the tools occasionally or not (Peixoto et al., 2014; Raz & Michael, 2001).

Tools to support the analysis, planning and control comprise certain costs, sometimes very significant. This cost concern to the effort required to understand and learn to use the tool. When the term tool is used it includes not only special purpose tools but also the practices and processes that contribute to risk management in projects (Raz & Michael, 2001).

## 2.5 Earned Value Management

Earned Value (EV) is used in performance reviews to measure and communicate the project performance against the schedule and cost baselines. The measurements resulting from an earned value analysis of the project indicate whether there are any potential deviations from the schedule and cost baselines. Earned Value Management (EVM) integrates cost and schedule control under the same framework and it provides performance variances and indexes which allow managers to forecast future performance and project completion dates and costs. EVM supports project risk assessment and control by measuring project evolution in monetary terms (Pajares & López-Paredes, 2011; Reichel, 2006; Vanhoucke, 2013).

The EVM allows the project manager to answer three questions (Vanhoucke, 2013):

- What is the difference between budgeted and actual costs?
- What is the current project status? Ahead of schedule or behind schedule?

- Given the current project performance, what is the expected remaining time and cost of the project?

To answer these questions there are three sources of data (Reichel, 2006):

- The budget (or planned) value of work scheduled;
- The actual value of the completed work;
- The “earned value” of the physical work completed.

EVM requires three key parameters to measure the project performance: Planned Value (PV), the Actual Cost (AC) and the Earned Value (EV) (Vanhoucke, 2013).

#### Planned Value

The PV describes how far along the project work should be at any point in the project schedule (Dummies, 2017; Reichel, 2006; Vanhoucke, 2013).

The PV is the sum of the approved budget for the activities scheduled to take place to date (Dummies, 2017). The PV is the baseline where project progress can be measured (PMI, 2011).

#### Actual Cost

In a project, the cost relative to the execution of the work is called AC. AC is the sum of the actual cost for activities performed to date. (Reichel, 2006; Vanhoucke, 2013).

The AC specifies the amount of resources consumed to reach the current work performed in each period (PMI, 2011).

#### Earned Value

EV is a measure of work performed. EV is the quantification of the value of the work done to date, that is, in physical terms, what the project accomplished. EV represents the sum of the budget for the activities carried out to date. (PMI, 2011; Reichel, 2006; Vanhoucke, 2013).

#### Variance Analysis

PMI defines variance as a measurable deviation of what is intended (known baseline or expected value). When the project is approved by the client or sponsor, then should be established to plan baseline or time-phased cost plan. The project manager must be informed of the actual cost incurred in the project work and the budgeted cost of the work performed on the project. Through these values can be performed a variance analysis (schedule and cost) (Reichel, 2006; Vanhoucke, 2013).

#### Schedule Variance

Schedule Variance (SV) status gives a measurement method since it indicates whether a project is ahead or behind the schedule (PMI, 2011).

The subtracting the PV from the EV describes the formula used to express schedule variance (Equation 1).

Equation 1 - Schedule Variance (SV).  
(PMI, 2011).

$$SV = EV - PV$$

If the variance is equal to 0, the project is on schedule. If a negative variance is determined, the project is late and if the variance is positive, the project is ahead of schedule (Reichel, 2006; Vanhoucke, 2013).

#### Cost Variance

The Cost Variance (CV) shows if a project is under or over budget. CV is defined as the difference between EV and AC.

Equation 2 - Cost Variance (CV).  
(PMI, 2011).

$$CV = EV - AC$$

If the variance is equal to 0, the project is on budget. If a negative variance is determined, the project is over budget and if the variance is positive the project is under budget (PMI, 2011; Reichel, 2006; Vanhoucke, 2013).

#### Schedule Performance Index

Schedule Performance Index (SPI) is defined as a measure of schedule efficiency on a project, in other words, how proficiently the project team is spending its time. The SPI is equal to EV divided by PV (Equation 3).

Equation 3 - Schedule Performance Index (SPI).  
(PMI, 2011).

$$SPI = \frac{EV}{PV}$$

An SPI equal to or greater than one indicates a positive condition and a value of less than one shows a critical condition (PMI, 2011; Reichel, 2006; Vanhoucke, 2013).

#### Cost Performance Index

The Cost Performance Index (CPI) is described as a measure of cost efficiency on a project, in other words, how proficiently the project team is spending its resources. The CPI is equal to EV divided by AC (Equation 4).

Equation 4 - Cost Performance Index (CPI).  
(PMI, 2011).

$$CPI = \frac{EV}{AC}$$



A CPI equal to or greater than one indicates a favourable condition (if much greater than one, it can be interpreted as bad planning though) and a value less than one indicates an unfavourable condition (PMI, 2011; Reichel, 2006; Vanhoucke, 2013).

Table 3 presents a summary of all topics mentioned before like CV, SV, CPI and SPI (Chung, 2017; Dummies, 2017; PMI, 2011).

Table 3 - EVM formulas.

Equation number	Name	Formula	Interpretation
1	Schedule Variance	Earned Value – Planned Value	<0: project behind schedule; =0: project on schedule; >0: project ahead of schedule
2	Cost Variance	Earned Value – Actual Cost	<0: project over budget; =0: project on budget; >0: project within budget.
3	Schedule Performance Index (SPI)	$\frac{\text{Earned Value}}{\text{Planned Value}}$	<1: project behind schedule; =1: project on schedule; >1: project ahead of schedule.
4	Cost Performance Index (CPI)	$\frac{\text{Earned Value}}{\text{Actual Cost}}$	<1: project over budget; =1: project on budget; >1: project under budget.

By monitoring the evolution of these indexes over the project life cycle, managers can take corrective actions as soon as deviations are detected (Pajares & López-Paredes, 2011).

Figure 6 displays the relationship between CV, SV, CPI and SPI.

Performance Measures		Schedule		
		SV > 0 & SPI > 1.0	SV = 0 & SPI = 1.0	SV < 0 & SPI < 1.0
Cost	CV > 0 & CPI > 1.0	Ahead of Schedule Under Budget	On Schedule Under Budget	Behind Schedule Under Budget
	CV = 0 & CPI = 1.0	Ahead of Schedule On Budget	On Schedule On Budget	Behind Schedule On Budget
	CV < 0 & CPI < 1.0	Ahead of Schedule Over Budget	On Schedule Over Budget	Behind Schedule Over Budget

Figure 6 - Interpretations of basic EVM performance measures. (PMI, 2011).

The EVM performance measures show how the project is about the planned work schedule and resource budget (Figure 6).

## **2.6 Key Performance Indicators**

The concept of success in projects has long been studied, but this key issue in project management is still poorly defined in terms of its concept and the necessary paths to achieve it (Belassi & Tukul, 1996; Crawford, 2002). For many years, the predominant vision of project success was focused on timely and cost-effective completion to deliver results that met the criteria established by the organisation. Currently, understanding what defines success or failure of the project is much more complex (C. Santos et al., 2014).

The success of a project and the success of project management are intertwined, but they are different concepts, and it is essential not to confuse the two (Bryde, 2003). Although project success is measured by the achievement of its objectives or by the effects of the project end product, project management success is evaluated on the basis of traditional performance measures (cost, time and quality) and is therefore easier to measure (Baccarini, 1999; DeWitt, 1998). Successful project management can lead to project success, but the reverse is not true (C. Santos et al., 2014). A project can be viewed as successful despite poor project management and vice versa (DeWitt, 1998).

Shenhar and Wideman (1996) identified seven main criteria to measure project success: technical performance, efficiency in project execution, organisational and management outputs (including customer satisfaction), personal growth, project completion, technical innovation and business performance, feasibility of manufacturing. The authors discuss the strong relationship between project success and customer approval and argue that project effects measurement can be performed in different time periods. Project objectives should be measured during project execution, customer benefits in the short term, project direct contribution in the medium term, and future growth opportunities in the long term.

Based on an older idea, Ika (2009) emphasizes that project success is measured by its efficiency and effectiveness. The first period of project management evolution (1960s-1980s) was characterised by the triangle (time, cost, quality); the second (1980s to 2000s) differentiated the relevance of customer satisfaction, organisational benefits, end-user satisfaction, stakeholder benefits, and project team benefits. In fact, success is also linked to the extent that the project is a strategic goal for the project owner and for the success of the business.

Schwalbe (2011) captured several perspectives in the literature about success and identified the following criteria to measure project success:

- Achievement of the scope, time and cost objectives: by the end of a project the expected estimates for these three variables must be achieved;
- Meeting customer and sponsor expectations: often more stringent than meeting established cost, schedule, and scope goals are end users and sponsor satisfaction;
- The main objectives of the project are achieved.

The notion of performance comprises three more specific concepts: efficiency, efficacy and effectiveness (T. Castro, 2000). Efficacy assess to what extent the objectives of an organisation were satisfied or not. Effectiveness measures the degree of satisfaction of the members of an organisation in terms of efficacy and efficiency. This is an indicator that requires increasing attention given the higher degree of qualification of employees of organisations. Efficiency, on the other hand, is to obtain the best possible result, using the fewest resources possible. Efficiency can then be summarized as a more rational utilization of means (T. Castro, 2000).

Performance evaluation is a strategic process that can be used as a management tool. The evaluation of performance in management aims to inform the company's current situation to top management and employees feedback on the work performed. Its main objectives are to improve productivity, motivation, the development of personal capacities and help in the decisions of organisation and management of the personnel (Andersen & Fagerhaug, 2001; Diridollou, 2002).

According to Andersen and Fagerhaug (2001), performance indicators are tools used to determine whether an organisation's objectives are met and whether it is moving towards the correct implementation of the organisation's strategy. Generally, these can be described as standards used to evaluate and communicate performance. Performance indicators are extremely important because they can portray value creation in an organisation.

For performance indicators to really have effect, they must follow three fundamental rules (Andersen & Fagerhaug, 2001):

- The metrics and objectives should be aligned with the organisation's objectives;
- The link between metrics and organisational goals should be revealed. This relationship must be evident so that everyone can understand it. The indicators should be simple so that each employee can see their impact on the overall performance of the organisation;
- Metrics should be monitored as only their measurement is not sufficient to ensure that the tasks assessed have actually been completed.

In implementing new performance indicators, the subsequent steps listed in Figure 7 should be followed (Andersen & Fagerhaug, 2001).

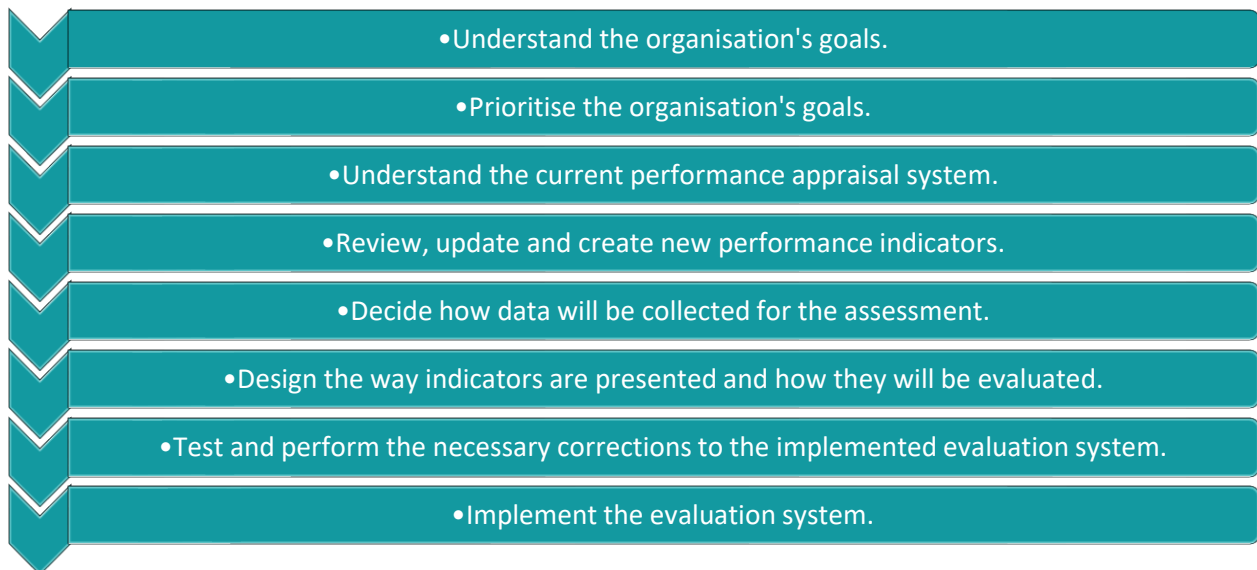


Figure 7 - Implementation of new performance indicators.  
(Andersen & Fagerhaug, 2001).

When implementing an indicator, it is necessary to assign it a target value, so that there is a benchmark for what is being measured. Constant goal compliance can mean that value should be revised and raised to a higher level of performance. For its part, the control limit is the minimum allowed value of an indicator, below which corrective measures must be immediately taken for the control. However, in some cases the control limit may be a permissible upper limit, in the case of the use of human resources being evaluated, for example, where excessive use could mean an overload of work (Andersen & Fagerhaug, 2001).

## 2.7 Visual Project Management

Regarding the way results are presented for further evaluation, it becomes pertinent to use formats that make the information synthetic, attractive and easy and quick to visualise. Cockpit charts are an eye-catching format that brings together various indicators in a visually appealing way, and enables to measure, monitor and manage effectiveness and progress in achieving goals in a comprehensive manner. A control panel groups the indicators into niches, depending on the architecture chosen, which will be based on the indicators and strategic objectives that they support (Ribeiro, 2015).

Cockpit charts are a form of alertness to easily detect deviations. For example, if any process is not progressing favourably, it is expected that the indicators of this process will change compared to normal values. However, since these correspond to a summary view, it will be necessary to start with a

detailed analysis of the factors that may be contributing to the reduction observed in a given indicator (Andersen & Fagerhaug, 2001).

In Figure 8 an example of a cockpit chart can be seen.



Figure 8 - Example of a cockpit chart. (Atlassian Jira, 2010)

In a simplistic way, the visual management of a project can be compared with the cockpit chart in a car, where a person can quickly see what happens in each function. In five minutes all the company's performance indicators can be covered. A restrict group of people have rights to access the tool as long as there is a close monitoring of these people that have access to the information available (Kerzner, 2011).

## 2.8 Software Tools for Project Management

Software tools can be used to record documentation, but are mostly applied in the planning phase of a project, to allocate resources to the various tasks, to define project schedules, to determine costs and to analyse risk. Tools can also assist in the execution and control phase, notably in exporting project data to other applications and creating key documents to support their execution, helping to monitor the progress of tasks and to study project performance in terms of work, time and costs (Feio, 2004).

While in the past the projects were restricted to a single location, with the globalisation of companies and the technological advance, the projects began to involve teams around the world. This environment leads to a negotiation of project objectives, scheduling, task allocation, parallel work and resource sharing. With traditional approach mistakes such as ineffective information flow between team members, distant project tracking, the reactive management approach and lack of documentation system lead to the failure or inefficiency of projects distributed across the globe (Chen, Briggs, Romano, &

Nunamaker, 2002; Chen, Romano, & Nunamaker, 2006; Evaristo & Fenema, 1999; Helbrough, 1995; Nunamaker, Romano, & Briggs, 2001).

The use of collaborative technology is also due to the increasing competitive pressure, in order to improve collaboration and knowledge sharing. It is important to use tools that support project management in an organisation, particularly when dealing with complex projects. In order to get an alignment between the stakeholders it is fundamental that the company has a philosophy of cooperation (Artail, 2006; Klimkeit, 2012; Rocha & Tereso, 2008).

Currently, due to its size, complexity, resources involved and associated costs it is absurd to manage a large project without the support of a computer. Nowadays, who wants to manage projects quickly and efficiently can only do so by using computer tools (Mian et al., 2008).

According to Conlin and Retik (1997), companies should take into account the following aspects when choosing the software package to be implemented:

- The user interface should be accessible to inexperienced users, but not too simplistic so as not to alienate experienced project managers;
- Monitoring capability of the project is another key feature. It should be possible to stop the project and insert the actual data so that they are confronted with what was planned;
- Another fundamental feature of software selection is the user's ability to specify the complete precedence relationships between activities (start-start, finish-finish, start-finish, finish-start) as well as time delays;
- Ability to allocate resources is a very important feature in project management tools. This importance becomes even more pronounced when the user demands control of resources and costs, avoiding delays;
- An essential feature that a computer package should have is the ability to report to people or managers who can study the information. The ability to produce reports is one of the distinguishing features of entry-level software for professional software;
- The ability to import and export data for inclusion in reports, charts, and/or databases is another very useful and important feature in selecting a computer package.

The reason why project collaborative platforms and tools are not typically accepted and/or properly used is due to individual and organisational practices rather than technical limitations (V. R. Santos et al., 2012).

## 2.9 Project Management in Industry

The Second World War was the origin of the modern project management and settled in a limited number of engineering based industries through the 1950s, 1960s and 1970s. More recently, the demand for project managers has grown rapidly, as project working has increased intensely in a broad range of industries (Lundin & Stablein, 2000). There is some evidence that such “industries of origin” are more mature in terms of project management than industries that have adopted the approach lately. The engineering industries do score more highly than industries that adopted project management as a core competency much more recently. Cooke-Davies and Arzymanow (2003) concludes saying that the results provide a clarified perception into the way that project management has developed differently when it is driven and formed in different environments.

The project management methodology is characterised by its efficiency in presenting good results in any economic segment. In industry this is not different, conversely, is one of the sectors that most use the methodology as pointed out by PMI (PMI, 2010). In a quickly expanding market with strong competition, no one admits that a new industrial project, regardless of size, is implemented without planning. PMI indicators show the increase of acceptance of the project management practices in companies (PMI, 2010). This fact stems from the recognition of the importance of project management for the transformation of business strategies into results. However, in some industries, improvisation is still a reality due to the lack of knowledge of the applicability of project management by the managers (Cruz, 2017).

Leadership capability of project managers, associated with a committed and technically qualified team, is necessary for a good project result. Organisational commitment, methodology, and project management tools complete the foundation for successful projects (Cruz, 2017).

The application of project management in an industrial organisation brings the emergence of the need for project teams and functional departments (production, marketing, finance, among others) to be integrated in order to provide a single organisational focal point and management system for project management. Project management techniques are used either for projects where their life duration can be extended over a number of years (projects in the aerospace industry), but these practices are also used to deal with short-term problems such as reduction of the division staff (Cleland, 1974).

For new product development projects, the project management method, with its structured task definition and software tools, is very useful. Complex interrelated activities and large uncertainties about precisely which solution path will be taken is characteristic to the development of new products. Another

important feature of new product development projects has to do with the need to consider cost and income (from product sales) in strategic decision-making (Pons, 2008).

### 2.9.1 Project Management in Manufacturing Industry

Regardless of the product or service, project management can be applied in any type of industry. In order to ensure that quality standards are met and the time to market is efficient, project management can be applied to the manufacturing process through the techniques of planning, scheduling, risk management, quality management, quality assurance, quality control and lessons learned (Bateman, 2012).

The sequential phases of project management life cycle support and intertwine in the product life cycle in manufacturing since both are process based. Therefore, project management becomes fundamental when it is desired to deliver a product that corresponds directly to its original requirements (Bateman, 2012).

All industries have critical stress points related to specific product or service being delivered. Depending on the industry these critical points may be different. The most typical critical points are schedule, cost, and quality. Focusing more on the manufacturing industry, it is the quality that needs more attention, since the quality fluctuates in each stage of each process and in all phases of the product being manufactured. Sometimes quality can give way to schedule as being the point to need more attention. This exchange of critical stress points can happen in cases of new product development or product updates (Bateman, 2012).

In order to better understand the benefits of project management in manufacturing industries, a survey with 251 senior executives in the manufacturing industries from around the world was carried out where the main results were as follows (Gale, 2010):

- When project managers report directly to senior executives, the project is more likely to meet the plan in terms of cost and time.
- The suitable project methodologies allow the team to have extra flexibility and reinforce the probability of success.
- The relevance of risk management is more notable in organisations with a mature approach to project management.
- Even with the right tools to manage risks and reduce errors, nothing replaces good oversight.



### 2.9.2 State-Gate Model

With the increase of competition as direct consequence of globalisation, product life cycles are decreasing in almost all technology-intensive industries (Jou, Chen, Hwang, Lin, & Huang, 2010).

Companies must deliver new products faster to stay competitive. Due to this fact, companies need to find more flexible conducts of managing product development without losing efficiency (Tatikonda & Rosenthal, 2000).

As the complexity of business processes increases, the importance of process models and methods for product development management becomes more evident (Browning & Ramasesh, 2007).

Most companies use some version of the Stage-Gate process (Cooper, 2014). Stage-Gate it is *“used to describe a point in a project or plan at which development can be examined and any important changes or decisions relating to costs, resources, profits, etc.”* (Cambridge University, 2017).

The original Stage-Gate system was created in the 1980s. Over the years, Stage-Gate has advanced and incorporated several new practices. These methodologies follow a sequence of the product development phases, normally it starts with the setting up of the idea, succeeding the development phase, further the execution phase and, at last the release/evaluation phase. Multiple research studies disclose that the Stage-Gate process has had a positive effect on the conception, development, and new products release (Cooper, 2014; Sommer, Hedegaard, Dukovska-Popovska, & Steger-Jensen, 2015).

Compared with informal development processes, Stage-Gate features advantages such as faster development, better quality, greater discipline, and better overall performance (Cooper, Edgett, & Kleinschmidt, 2002a).



### 3. RESEARCH METHODOLOGY

This chapter presents an overview of the methodological approaches for business and management research: the philosophies, approaches, strategies, choices, time horizons, techniques and procedures. Then, in a general way, presents and discusses the choices made for this master's dissertation.

This chapter is based on the book of Saunders, Lewis, and Thornhill (2009).

#### 3.1 Research methodology for business and management research: an overview

Defining the research methodology to be used is fundamental for the researcher, since it guides and allows the most appropriate strategy planning to reach the objectives of the dissertation project.

The research methodology can be seen as a set of multiple layers (Figure 9), starting with the research philosophies, followed by approaches, strategies, choices, time horizons, and techniques and procedures.

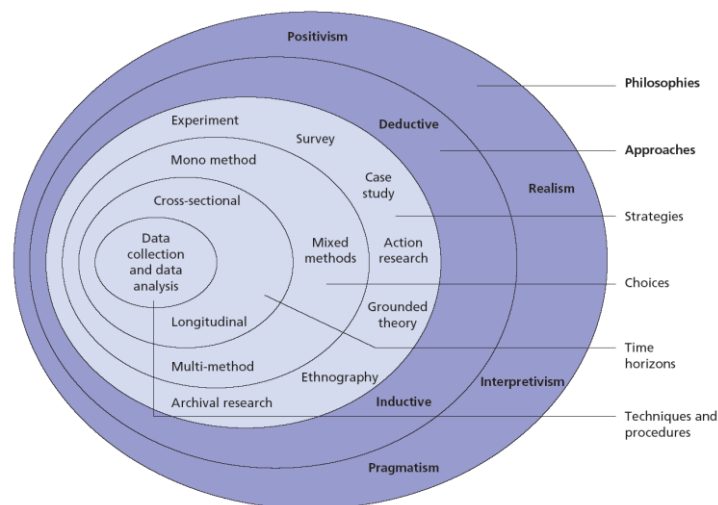


Figure 9 - The research "onion".  
(Saunders et al., 2009).

#### Philosophies

According to the authors, practical considerations influence the philosophy to adopt, therefore the philosophy adopted impacts the choices of internal layers.

The most common types of philosophy are positivism, realism, interpretivism, and pragmatism. It is important to have a clear and succinct notion of these concepts:

- Positivism: Assume the philosophical posture of the natural scientist. Only observable phenomena lead to the production of credible data. The emphasis will be on quantifiable

observations that lend themselves to statistical analysis. The end result of this type of investigation will be generalisations in the form of laws.

- Realism: Related to scientific enquiry. The core of realism is that the objects have an existence independent of the human mind, that is, what the senses show us as being reality is the truth.
- Interpretivism: Follows the intellectual tradition that claims that we are in a continuous process of interpreting the social world that surrounds us, which leads to the adjustment and definition of meanings and actions. Supports that it is necessary for the researcher to understand differences individuals in their role as social actors. The researcher has to adopt an empathetic stance.
- Pragmatism: This philosophy says that the most important of the epistemology, ontology and axiology adopted is the research question - one may be more appropriate than the other to answer particular questions. This strategy states that it is possible to work in both positivist and interpretive positions. A practical approach is applied, integrating different perspectives to help collect and understand data.

### Approaches

The research approach could be deductive or inductive. The deductive approach starts with a theoretical or conceptual framework, which was developed by theories and ideas based on the literature review, to later on, test hypothesis using data. On the other hand, the inductive approach consists in deliberate and explore data, which will help the development of theories from the analysis of facts. Although research has a clearly defined purpose with research questions and objectives, it does not begin with any predetermined theories or conceptual frameworks.

### Strategies

The choice of research strategy will be guided by research questions and objectives, the extent of existing knowledge, the amount of time and other resources available, as well as the philosophical foundations themselves. According to the authors, there is a variety of research strategies:

- Experiment: A practice of research that owes much to the natural sciences. An experiment typically involves: hypothesis definition, selection of samples from known populations, sample allocation to different experimental conditions, introduction of planned changes in one or more variables, measurement of variables under analysis and the control of all other variables.
- Survey: This strategy is usually linked with the deductive approach. A survey allows the collection of data from a population in a very economical way. This research strategy allows gathering quantitative data to analyse quantitatively using descriptive and inferential statistics.

Structured observation and interviews, where standardized questions are asked of all respondents, often fit into this strategy.

- Case study: Robson (2002) defines case study as a strategy for undertaking research that involves an empirical investigation of a specific contemporary phenomenon within its actual context using multiple sources of evidence. Yin (2009) also highlights the importance of context, adding that within a case study the borders between the phenomenon studied and the context within which it is being studied are not clearly obvious.
- Action Research: This strategy is an approach to research that aims to take action and create knowledge or theory about this action (Coughlan & Coughlan, 2002). It focuses and emphasizes the purpose of research: research in action rather than research about action. Action research is a both of sequence of events and a problem-solving approach. As a sequence of events, it comprises iterative cycles of data collection, returning them to stakeholders, analysing data, planning actions, taking measurements and evaluating, leading to more data, and so on (Figure 10).

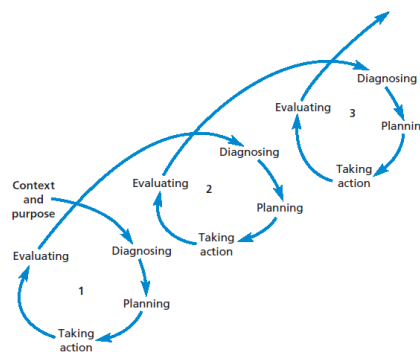


Figure 10 - The action research spiral.  
(Saunders et al., 2009).

The members of the studied system participate actively in the cyclical process (Figure 10). The goal of this strategy is to take actions and generate knowledge.

- Grounded Theory: Employs a systematic procedure to develop a theory about a particular phenomenon. This theory is developed from data generated by a series of observations. In a simplistic way, it is often considered the best example of the inductive approach.
- Ethnography: It is the inductive approach that underlies ethnography. The purpose of this strategy is to describe and explain the social world that the research subjects inhabit in the way they would describe and explain it. Presupposes a prolonged experience of the researcher with the subjects of the subject of the study, is based on observations. The research process must be flexible and responsive to change.

- Archival Research: It allows research questions that focus on the past and changes over time to be answered, however, the ability to respond to those questions will inevitably be limited, because this strategy is based on the analysis of administrative records and documents as the main source and data.

### Choices

When using only a single technique for collecting quantitative data such as questionnaires, quantitative data analysis procedures, or a unique qualitative data collection technique, such as in-depth interviews with qualitative data analysis procedures, this is a mono method. Choosing to combine data collection techniques and procedures using some form of multi-method design, this refers to combinations where more than one data collection technique is used with associated analysis techniques, but this is restricted within a quantitative or qualitative world view. Yet, there is another approach known by mixed methods. This is used when, in a research project, both techniques quantitative and qualitative data collection are used.

### Time horizons

Time horizons to research design are independent of the research strategy used or the method chosen. Depending on the time of the study time horizons of the research can be longitudinal or cross-sectional.

Cross-sectional studies are like photographic moments. These are studies located in time. The same phenomenon is studied in different organisations at the same time. Longitudinal studies take place over time allowing the study of change and development, the same phenomenon is studied in different periods of time.

### Techniques and procedures

The data collection methods used can be categorized in qualitative or quantitative procedures.

According to Creswell (2013), qualitative research involves emerging questions and procedures. The data is classically collected in the participant's setting and the investigator makes interpretations of the meaning of the data. On the other hand, quantitative research tests objective theories by examining the relationship between variables that can be measured. Therefore, data can be studied by statistical procedures.

**3.2 Research methodology: choices made**

The methods on focus to develop this master’s dissertation are:

- Observation: it is a method of data collection where the researcher takes field notes about the behaviour and activities of individuals at the research site, and about the specific location. In this master’s dissertation, observation was a very important technique since it was necessary evaluate how some procedures are done in CM/MFT3. For example, observation helps to define the topics to be explored in interviews. It is also through observation that the main failures of the section were detected.
- Interviews: help in collecting valid and reliable data that is relevant to the research questions and objectives. It can be structured (based on a predetermined questionnaire), semi-structured (the researcher has some themes and questions that need to be answered) or unstructured (informal, free conversation). In this master’s dissertation some interviews were done, all of them unstructured interviews (free conversation) where it is discussed different themes or subjects. Interviews are important since they enable problems identification that through observation would not be identified.
- Document analysis: is related to the analysis of the content of documentary materials (books, reports, newspapers, letters, e-mails, etc.). In this master’s dissertation, the document analysis is useful since the documents are interpreted, the failures are detected and final solutions are proposed and, if possible, implemented.

Table 4 summarizes all the choices made for the research methodology to be used in this master’s dissertation.

Table 4 - Methodological choices summary.

		Explanation of the choice
Philosophies	Pragmatism	This philosophy is the most adequate for this master’s dissertation since it defends that the most important of the epistemology, ontology and axiology adopted is the research question: “How can the monitoring and control of projects be improved in a section of an automotive company?”. In this master’s dissertation, a practical approach is applied, integrating different perspectives to help collect and understand data.
Approaches	Inductive	The approach adopted in the dissertation is inductive, since it starts from observations of a specific context toward more general conclusions. It was used the research question to narrow the scope of the study (like supports the inductive approach).

Strategies	Action Research	Action research was the most appropriate strategy for this master's dissertation since it is indicated for who choose a problem of the organisation where they are inserted as the focus of their study. This dissertation was based on the development of a collaboration between the researcher and the elements of the organisation, in order to diagnose and solve a problem of special relevance to the organisation. An iterative process of problem identification, planning, action and evaluation was used.
Choices	Mixed Methods	In this dissertation, techniques for collecting and analysing quantitative (quantifiable aspects as KPIs) and qualitative (observation methodologies, unstructured interviewing and supplementary information drawn from wide range of sources, i.e. written evidence, visual material, and so on) data were used.
Time horizons	Cross-sectional	This research is limited in time, since, it is held in a semester.
Techniques and procedures	Observation; Interviews; Document Analysis.	The techniques used in this master's dissertation were observation (was a very rich form of data collection in order to understand how project management practices were in CM/MFT3); Interviews (meetings that occur with an agenda of subjects to be covered but no specific questions) and Document Analysis (documents used for project management were analysed.).

In this master's dissertation, the main problem to address were the poor practices of CM/MFT3 section with regard to project management. Project management is a new knowledge area that appeared in 2013 in the section due to the emergence of projects requesting more rigorous project management practices.

Chapter 5 presents the current situation of CM/MFT3 in order to understand the main difficulties found in the section. Then, it was necessary to understand how the identified problems could be solved. For this purpose, several observations, meetings and document analysis were done.

A documental analysis was developed using the documents and the information available in the section. The main objective of this documental analysis was to understand the type of information managed and documents produced in the section. The last technique used was the direct observation of the current practices used by the collaborators, which allowed understanding what they consider more difficult in their work.

Meetings were held in order to complete the analysis of the current situation, with inputs, especially of the project manager. Based on the analysis of documents and the meetings, some improvements were



proposed. These meetings were intended to monitor the status of proposals, and if necessary, to adjust some points.

The methodology for data collection, Figure 11, for all proposals, was as follows: observation of the practices used in CM/MFT3, analysis of the documents used before in the section, then meetings with CM/MFT3 collaborators were held in order to better understand the problem and propose improvements. Finally, meetings were held at least once a week in order to follow the status of the work and adjust the proposals if necessary. The methodology used is based on the cycles of Action Research (diagnosing, planning, taking action and evaluation).



Figure 11 - Data collection.



## 4. BOSCH GROUP

This chapter describes the business context in which this master’s dissertation was developed. In the beginning of this chapter, the company, Bosch, the division, Car Multimedia, and the section, CM/MFT3, are briefly presented. Also, the project management practices adopted by the company are discussed, mainly the ones used in the section.

### 4.1 Bosch Worldwide

In 1886, Robert Bosch founded the “Workshop for Precision Mechanics and Electrical Engineering” in Stuttgart. This was the birth of today’s globally active Robert Bosch GmbH. From the foundation, the company’s history has been characterised by ground-breaking drive and social commitment. Figure 12 highlights the 130 years of Bosch history (Bosch, 2017f).

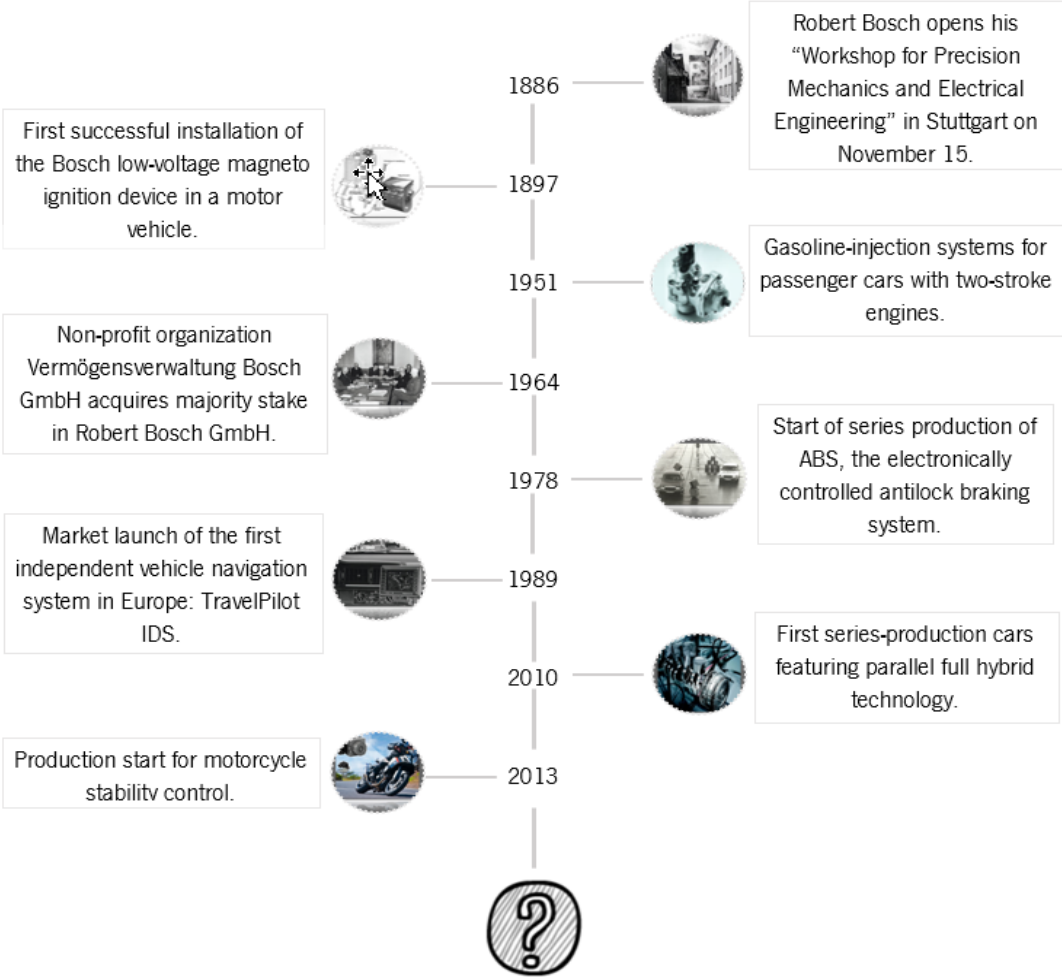


Figure 12 - Bosch history.  
Source: Author’s own elaboration.

The Bosch Group is a leading global supplier of technology and services. In December 2016, the company employs roughly 390,000 associates worldwide. The company generated sales of 73.1 billion euros in 2016 (Bosch, 2017e). Its operations are divided into four business sectors as can be seen in Figure 13.



Figure 13 - Bosch business sectors.  
Adapted from: Bosch (2017g)

The Bosch’s Group strategic objective is to create solutions for a connected life, and to improve quality of life worldwide with products and services that are innovative and spark enthusiasm. In short, Bosch creates technology that is “Invented for life”. The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiaries and regional companies in some 60 countries. Including sales and service partners, Bosch’s global manufacturing, engineering, and sales network covers nearly every country in the world. The basis for the company’s future growth is its innovative strength. At 120 engineering locations worldwide across the globe, Bosch employs 59,000 associates in research and development (Bosch, 2017e).

## 4.2 Bosch Car Multimedia Portugal

Established in Portugal since 1911, Robert Bosch, S.A. is a subsidiary of Robert Bosch GmbH. With around 3.967 associates, Bosch is one of the largest industrial employers in Portugal and created, in 2016, 1.1 billion euros in sales. Around 95% of its production is distributed globally to over 60 countries, which makes Bosch one of the top 10 exporters in Portugal (Bosch, 2017a, 2017e).

Bosch is represented in Portugal (Figure 14) by Bosch Thermotechnology, S.A., in Aveiro, Bosch Car Multimedia Portugal, S.A., in Braga, and Bosch Security Systems in Ovar, developing and producing a wide range of products, namely hot water solutions, car multimedia, and security and communications systems, most of it exported to international markets. The Group also has a sales office and a BSH Appliances branch, both located in Lisbon (Bosch, 2017c).

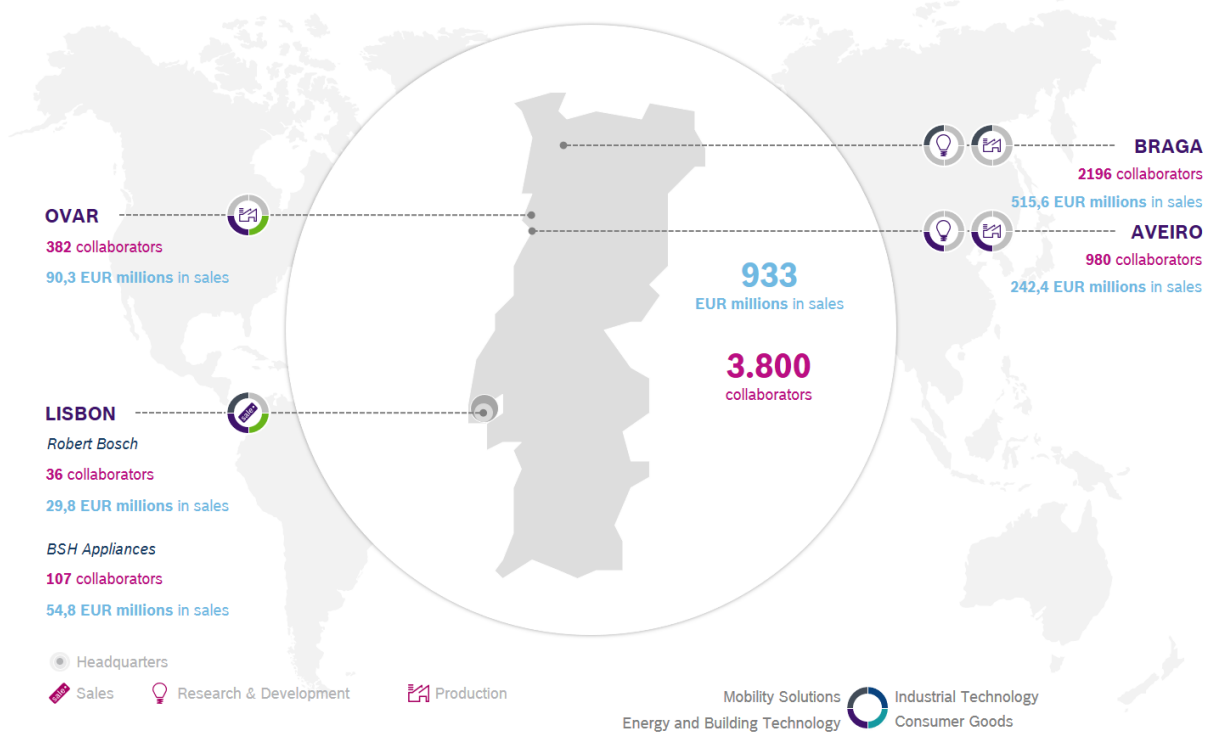


Figure 14 - Bosch in Portugal.  
Adapted from: Bosch (2016a).

Bosch Car Multimedia develops smart integration solutions for entertainment, navigation, telematics and driver assistance functions used in the original equipment business. The needs of the driver are always at the focus of all research and development activities to create technologies that enhance safety and driving convenience and at the same time reduce energy consumption (Bosch, 2017d).

The plant located in Braga has a Research & Development department, an Electronic Service, a Centre of Bosch IT and Electronic Services, both responsible for Iberia. Bosch Car Multimedia Portugal S.A. is also a Competence Centre for the European market (Bosch, 2017b).

The management of Car Multimedia (CM) division is separated in commercial and technical areas that encompass the different departments of CM (Figure 15).

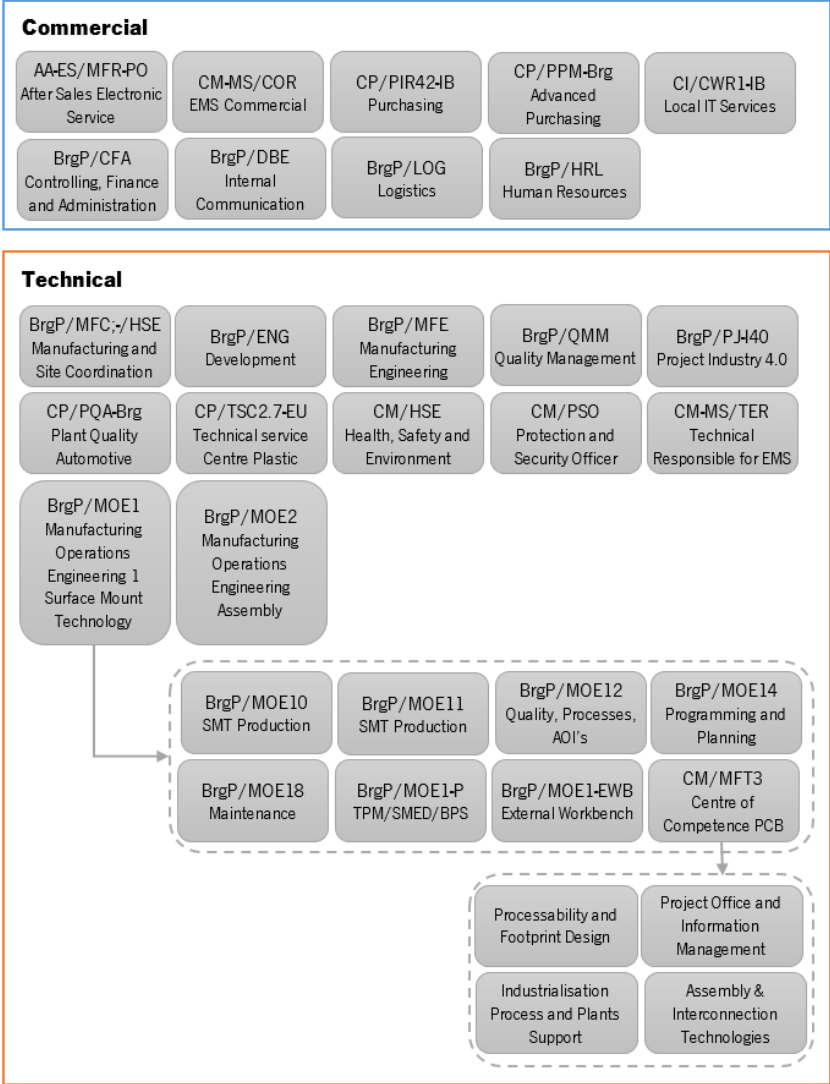


Figure 15 - Braga location management.  
Source: Author's own elaboration.

This dissertation was developed in the section CM/MFT3. This section is worldwide responsible in the area of PCB Assembly and Interconnection Technologies and pertains to a centralised organisation in Hildesheim.

The section is structured into four different areas, according to the work developed. The area of Project Office and Information Management is responsible for the incorporation of all areas in order to have the work developed in the section linked, which makes essential the collaboration and good communication of all sections' collaborators even if they work in separated areas (Bosch, 2015b).

### 4.3 Project Management at Bosch

Customers and internal projects are increasing in their size, international dependencies, and complexity over the past years. In addition, more and more activities outside new product development are conducted as projects. Consequently, the professional management of projects and its Bosch-wide internalisation has become a key success factor for superior project results (Bosch, 2016c).

Bosch considers project management as a core competence. In order to improve and standardise it, Bosch created a central directive named “Project Management at Bosch” and a book “Robert Bosch Project Management Body of Knowledge” (RBPM-BoK) based on PMBoK of PMI (Bosch, 2016c). These directives are universally valid and applicable for all Bosch companies distributed around the world.

Project Management (PM) definitions adopted by Bosch are very similar to PMI’s definitions presented previously, in literature review. The project definition adopted by Bosch is: *“a project has a beginning and an end and contains sufficient uncertainty (risk) associated with the project outcome to require project management”* (Bosch, 2016c). At Bosch, PM is applied in different projects, e.g. product engineering/development projects, software and manufacturing projects, organisational development project, etc. In Bosch there are two types of projects: Production Engineering Process (PEP) when the project is related with the development of a new product (e.g. project for Porsche E3) and Production Process Development (NonPEP) when the project is independent of the product where it will be applied, that is, even if there is a product associated with the project, this project can be applied to other products (for example, strategic projects, development of new processes, innovative projects).

During this dissertation the words project and product will be used in several situations. In CM/MFT3 these can be understood as follows:

- Project: development of new processes (press-fit; laser depaneling); development of new materials (underfilling, conformal coating); innovative projects; strategic projects; among others.
- Products: display of Porsche E3; radio of Jaguar; among others.

In CM/MFT3 section the type of projects studied was the one related to production process development (NonPEP), which has the project life cycle shown in Figure 16. These projects follow CM Directive: Production process development.

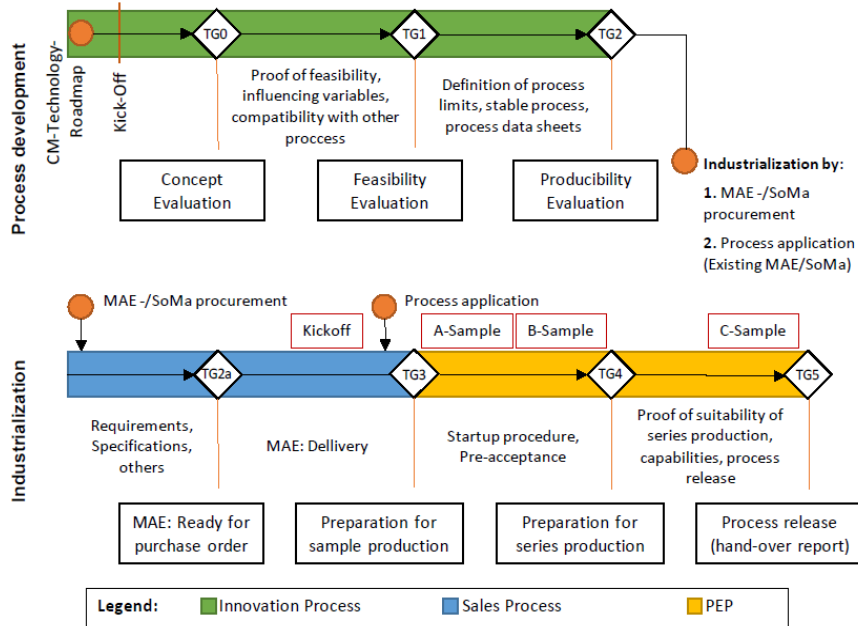


Figure 16 - Project life cycle for production process development projects (nonPEP).  
( Bosch 2016a).

Technology Gates (TGs) are milestones used as a quality tool and access the assurance of the production process development from the beginning until the end of the project. At the end of each phase a TG is performed to evaluate the work done. It is not necessary to do all the TGs mentioned in Figure 16. The mandatory TGs depend on project type (Table 5) (Bosch, 2016b).

Projects must be categorised regarding their impact to the operating unit. The first approach is to classify if the task is considered a project or not. To be a project, it has to accomplish the following requirements (Bosch, 2016c):

- Unique and limited in time;
- The results constitute a new status;
- The time exceeds six months;
- The results are also used by other departments;
- It is needed a separate budget;
- Resources from other departments are also required;
- The sponsor demands project monitoring in a steering committee or costs exceed 50.000€.

If the project contents those requirements, it can be further classified as type A, B or C, according to the characteristics shown in Table 5. In Table 5, it is also shown which TGs are mandatory (M.) or optional (O.) according to the project type. Non-projects do not have to do TGs, they are optional (Bosch, 2015b).



Table 5 - Mandatory TGs according to the types of CM Projects.  
Adapted from: Bosch (2015b).

		TGs							Characteristics
		TG0	TG1	TG2	TG2a	TG3	TG4	TG5	
Project Type	A	M.	M.	M.	M.	M.	M.	M.	Long-term impact to CM. New in new framework. Multiple fields of expertise. Highly complex structures. Core competence.
	B	M.	O.	M.	O.	M.	O.	M.	Mid-term impact to CM. New within existing framework. Several fields of expertise. With few sub-projects. Key competence.
	C	M.	O.	O.	O.	M.	O.	M.	Short-term impact to CM. None innovation. One field of expertise. Without sub-projects. Standard competence.

Legend: M. – Mandatory, O. – Optional.

In TG0, the project concept is assessed and the main documents (project charter, schedule, among others) are analysed. It happens in the first kick-off meeting.

It is in the TG1 that the project goes into more detail, searching for the matching between the customer requirements and the section. The last stage of planning happens in TG2, and the risks identified are assessed. Some risks can influence the schedule for example. In this milestone it is advisable to have, already, an outline of the process flow in production.

The TG2a only happens when the project involves the purchase of a new Machinery And Equipment (MAE). In TG2a, the equipment is validated, the contract documents are created, the market is evaluated, suppliers are selected and finally the purchase of the equipment takes place.

The processability validation occurs in TG3. This means that the evaluation of process capability indexes required by the Bosch standards is made in this phase.

Reliability is evaluated in TG4 in order to comply with the quality assurance given to the customer. The TG4 is a very important milestone since it is on this step that the TG4 of de project needs to be aligned with the product C-Sample (in this sample it is evaluated if the production line is representative for mass production). In other words, it is on this TG that requirements are verified for product development (product design specification, product drawings, production processes, material, test instructions, etc.) and tested for mass production suitability.

For TG5 audit realisation, the handover report, which consists of the project output, must be released and approved.

Since the implementation of PM in the section, in 2013, its importance has been growing. In this section, the project management area is in the centre of all activities. In addition, all areas are related with each other showing that communication is an essential point to maximise and improve the work developed at CM/MFT3.

#### **4.4 Track&Release: an official Bosch tool**

“Inside.Track&Release” is a Bosch tool powered by Atlassian JIRA. Track&Release (T&R) is a web-based application that guarantees a professional, systematic and effective management of tasks (like Open Point List (OPL), software bugs, project tasks, change requests, improvements) of any kind. It is a superior solution for the reliable planning and tracking of duties (Bosch, 2015b).

Optionally, the plugin Agile Boards can be added to an inside.Track&Release project providing the project with boards and sprints for easier planning and visualisation of issues using Scrum or Kanban methodologies.

“Inside.Track&Release Agile” is an add-on that subjoins a broad collection of agile project management competences to “inside.Track&Release”, and extends “inside.Track&Release” as a platform for agile development teams.

The main objective of this tool is to represent open point lists of a project through automatic synchronisation to Docupedia (Docupedia is a platform to share information online, similar to a web-page).

With “inside.Track&Release” it is possible have an eye on the most important tasks. The benefits of this tool are represented in Figure 17.

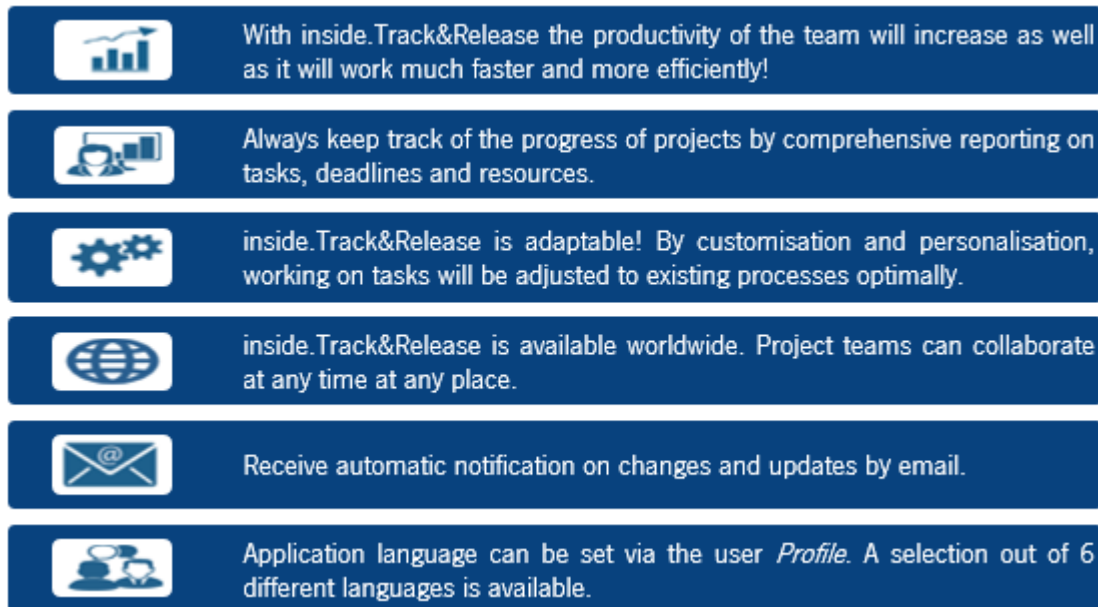


Figure 17 - Advantages of Track&Release.  
Adapted from: Bosch (2015a).

In order to understand what has been developed it is necessary to introduce some concepts used in Track&Release, such as components, filters and Gantt-Chart.

#### 4.4.1 Components

Components are a subsection of a project that collects issues in smaller groups allowing management and categorisation of issues in a better way. Only administrators can create components but they should analyse their utility first. It is advisable the creation of the smallest possible number of components to simplify their management.

The component should have a leader that is the collaborator responsible for the activity or process or, in case of a project, the project manager. Each issue is part of a project and can be associated with one or more components.

The components are divided for better management. The components are:

- Each project - The project manager is the owner of the component;
- Each process - Each CoC is the owner of the component of its processes;
- Each product (display for Porsche E3; display for Lamborghini; among others);
- Other activities.

The type of issues in Track&Release are task, meeting, request, cost, analysis and Component Processability Release (CPR) (Figure 18).

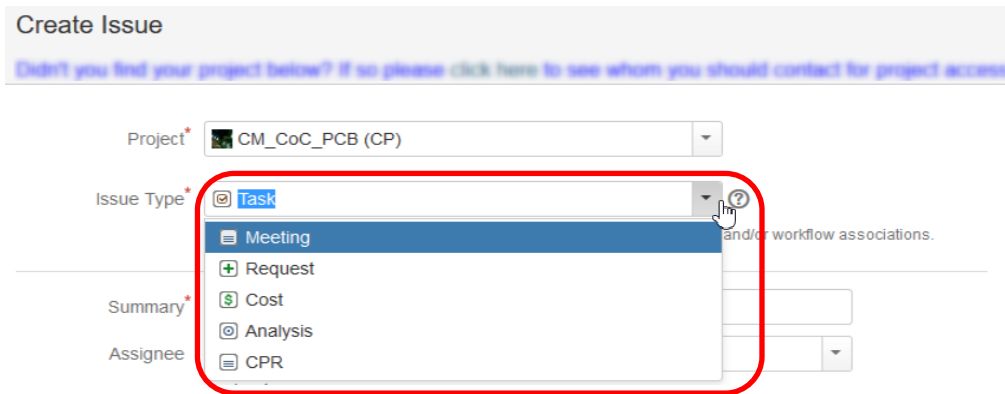


Figure 18 - Create an issue.

To create a component with project name and project manager as component lead (Figure 19), it is mandatory to put the project code in the name (YY\_RMPXX, where YY refers to the year of the roadmap where the project was approved; RMP means roadmap and XX indicates de number of the project attributed by the section, for example: 17\_RMP20 Project A).

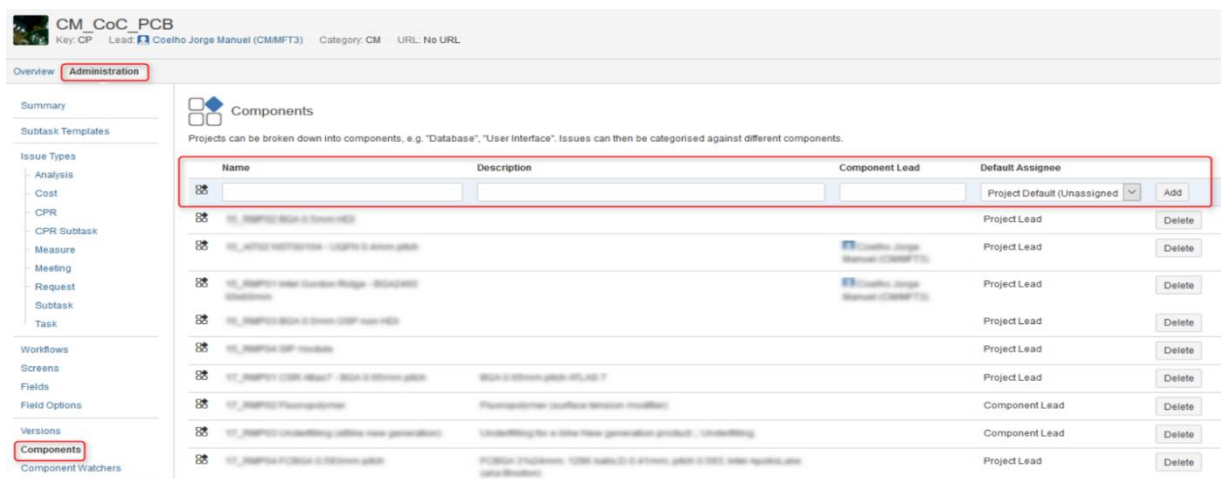


Figure 19 - Create a component.

Additionally, it is possible to do a search in T&R by component: to do this it is necessary to press the button “components” in the main page. Choose the component and click on it to see all the issue associated.

#### 4.4.2 Filters

Issues can be filtered in many ways: general filtering, component filtering, Kanban board filtering and Gantt-Chart filtering.

Searching by filters can be useful because it is possible to filter issues assigned to a particular person and add some other filters such as issue type, component, reporter and so on.

To create a filter, it is possible to choose many fields, as shown in Table 6:

Table 6 - Fields for creating filters.

Type	Status	Assignee	Components	Other fields
Analysis	Open	Current User	Project	
CPR	In progress	Unassigned	Products	
Cost	Reopened	Others	Others	
Meeting	Closed			
Request	On hold			
Task	Approval			

For example, if it is necessary to see the tasks in progress that are occurring in a specific project, the fields available to choose from can be seen in Figure 20:

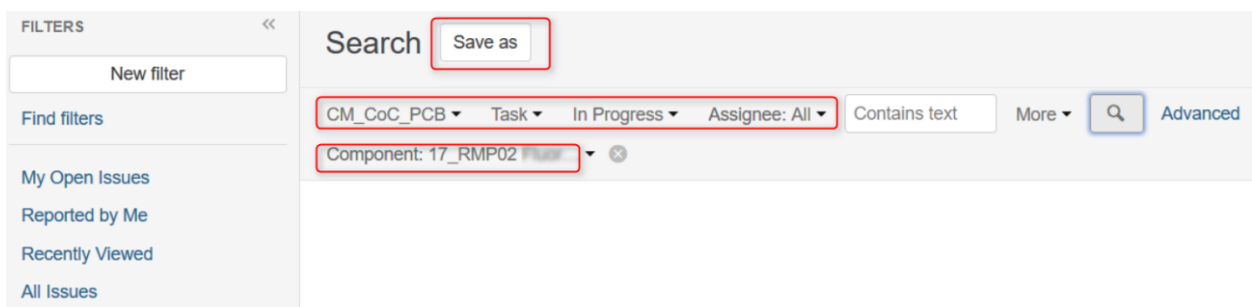


Figure 20 - Creating a filter.

A quick filter can be created by saving it after the search (Figure 21). Then, the filters will appear on “favourite filters” and will be faster to find by just clicking on them.

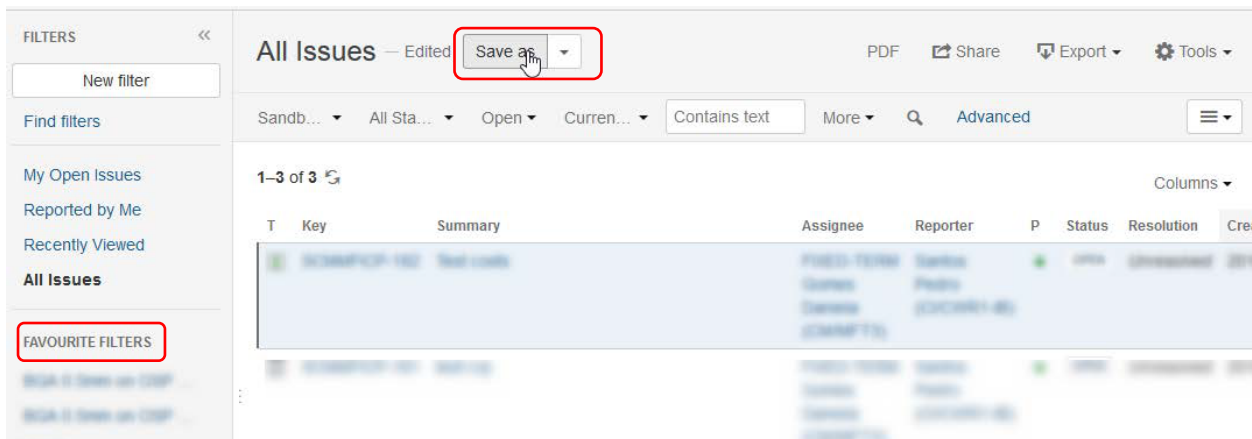


Figure 21 - Save a filter.

#### 4.4.3 Gantt-Chart

WBS Gantt-Chart allows an improved vision of issues through time lines.

When the WBS Gantt-Chart option is pressed, many options to choose a filter appear. For these filters to appear, they have to be saved first. It is possible to do a visual search in Gantt-Chart (Figure 22).

The WBS Gantt-Chart only has utility if the issues status are always updated.

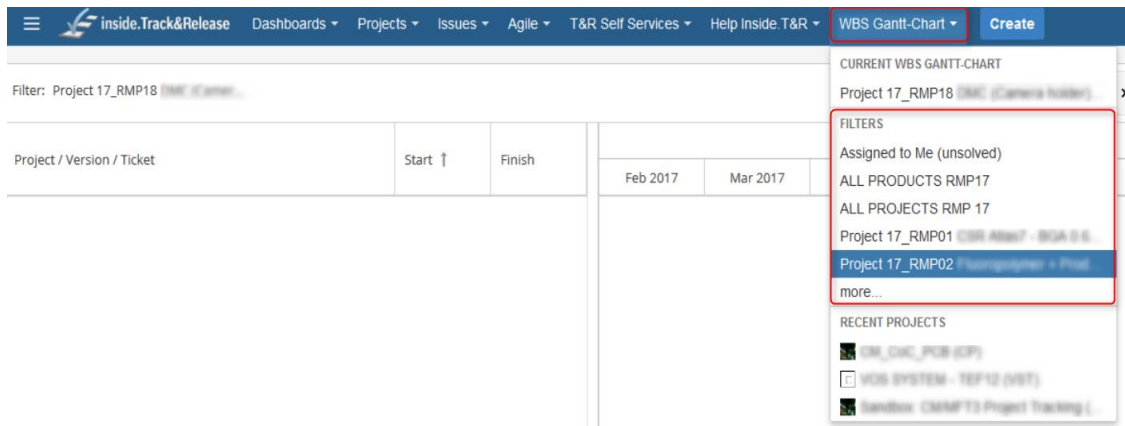


Figure 22 - WBS Gantt-Chart options.

In addition to having the time lines, the Gantt-Chart view also has many columns with different information that can be chosen by any arrow in the column header (Figure 23).

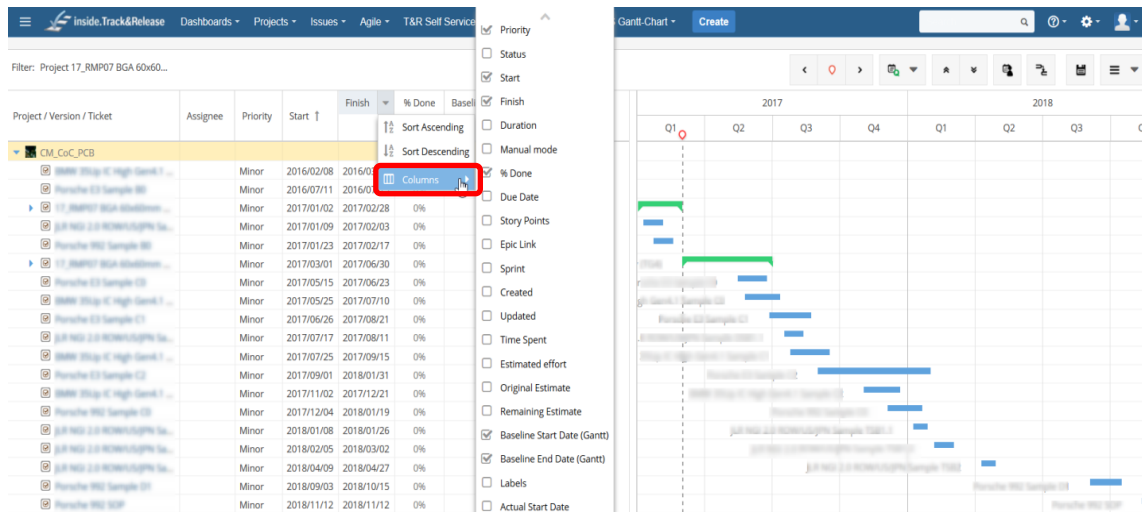


Figure 23 - Gantt-Chart view.

**5. ACTUAL STATUS**

Before proceeding to any proposal for improvement, it is necessary to study and evaluate the status of project management in the CM/MFT3 section. For this phase of evaluation of the current state to be successful, it was necessary to hold weekly meetings with the collaborators of the section and perform an analysis of documents and observation. The meetings took approximately one-and-a-half hours and occurred in the first four months of the research work. They were a starting point to enable the achievements reported in the next chapter.

**5.1 Tool for the overview of projects-products crossings**

With the increase in the number of projects that fall under the supervision of CM/MFT3, tools that were used to track few projects are no longer adequate. This was the first and main problem encountered in the CM/MFT3 section, managing and monitoring projects. The documents used to track projects were getting too heavy, difficult to maintain, and not intuitive.

When project management practices started in CM/MFT3, in 2013, the number of projects did not exceed two; a year later the number of projects rose to four; by 2015 the section had eight projects under supervision. During 2016 the number of projects to be managed reached eleven; in the current year the number of planned projects has reached sixteen (Figure 24), and it is also likely that more (unplanned) projects will fall under supervision of the section.

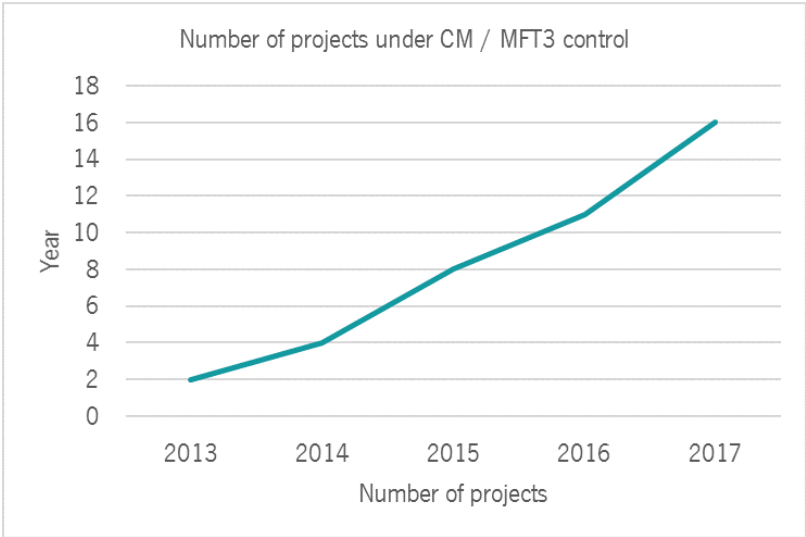


Figure 24 - Number of projects under CM/MFT3 control.

In Figure 25 it is possible to analyse the uncontrolled growth that the file had to suffer with the increase of the number of projects for the year 2017.

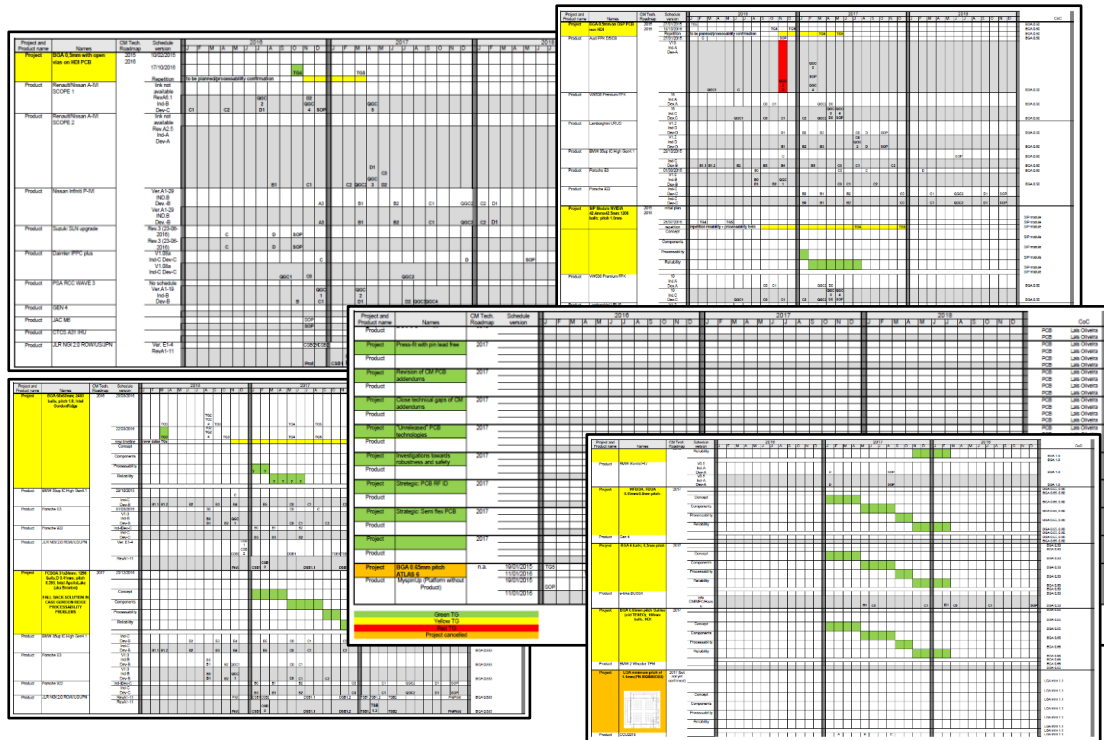


Figure 25 - Tool to track and control projects in 2017.

Figure 25 represents only some A3 sheets created to aid in project management. In this file, it is very difficult to analyse the number of projects under section management, the cross analysis between projects and the products in which they are involved, the overlapping of activities over time and the crossing between the project schedule and the products schedule. Note that this Excel table has 480 lines!

As a consequence of the increase in the number of projects from one year to the next, 2013 with about two projects and 2017 with more than sixteen (Figure 24), it became clear that the file presented had to be improved since it is becoming very complex, difficult to update and no longer been appropriate for the duties it was intended for. The main problems encountered in this file are:

- To know the total number of projects it is necessary to scan more than 480 lines (in Excel format) and ten more sheets in A3 format (when the table in Excel was printed);
- Too much information, sometimes repeated (products information repeated over the file);
- It is not possible to cross different projects' schedules (the products are described in the middle of the list of projects in which will have influence);
- The overlapping of activities becomes very difficult to observe due to the size of the document;
- In this document some reworking is needed. For example, product A is involved in project X, Y, and Z. If the version of product A changes, it is necessary to look at the document, see in which



projects this product is involved (in this case projects X, Y, and Z) and then make an update of the three projects.

## 5.2 Tool for the project status overview

The section considers important to have available an overview in order to assess the status of the projects as shown in Figure 26.

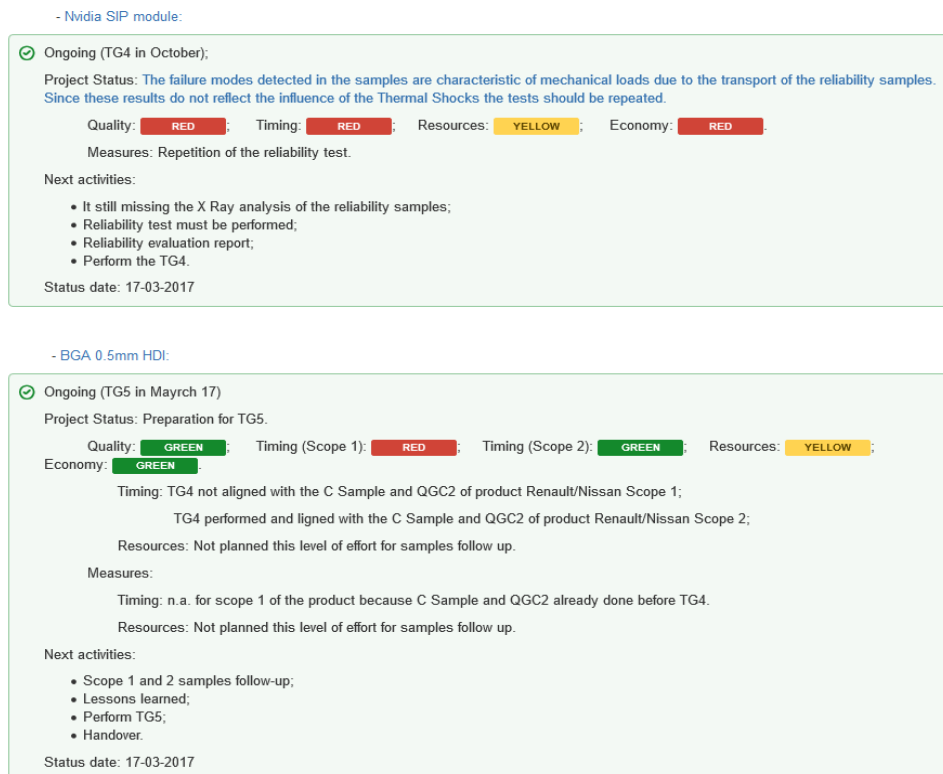


Figure 26 - Overview of project status.

Projects are marked by four previously defined characteristics (constraints): Quality, Timing, Resources and Economy. However, there is not a way to show the full overview of all projects. At the moment only the status of individual projects can be analysed.

This individual analysis of the project situation reflects a bit the low maturity level of the section in terms of project management. There are no clear and well-defined rules or criteria for the characterisation of traffic lights (Green, Yellow and Red). For example, the characterisation of what means a red in quality or timing is not defined. To provide this overview, the data is discussed in meetings and through the perception of those involved, it is decided whether the timing, for example, will be characterised as red, yellow or green.

Key Performance Indicators (KPIs) are essential in project management. These indicators facilitate the management of the projects and indicate their status. In CM/MFT3, these performance indicators are not defined.

With the absence of KPIs and the lack of tools that follow closely projects, it is difficult to do good control practice in project management in terms of time, cost, quality and resource planning.

### 5.3 Risk Management

The section decided to use a tool provided by Diesel Systems in 2013. After document analysis and observation, some nonconformities were detected in the way meetings are conducted for the preparation of risk analysis. Bosch has developed some risk management standards for projects that are not being fully met by the section. These standards define the processes applied for identifying and evaluating project risks and tracking any measures installed for risk mitigation – thus ensuring an orderly, systematic approach for dealing with risks emerging during project management at CM.

In the tool used by the section, the user can enter the new Risk by navigating in the menu Risk/Measures-New Risk/Measures.

Figure 27 shows the risk data entry screen of the tool used by the section.

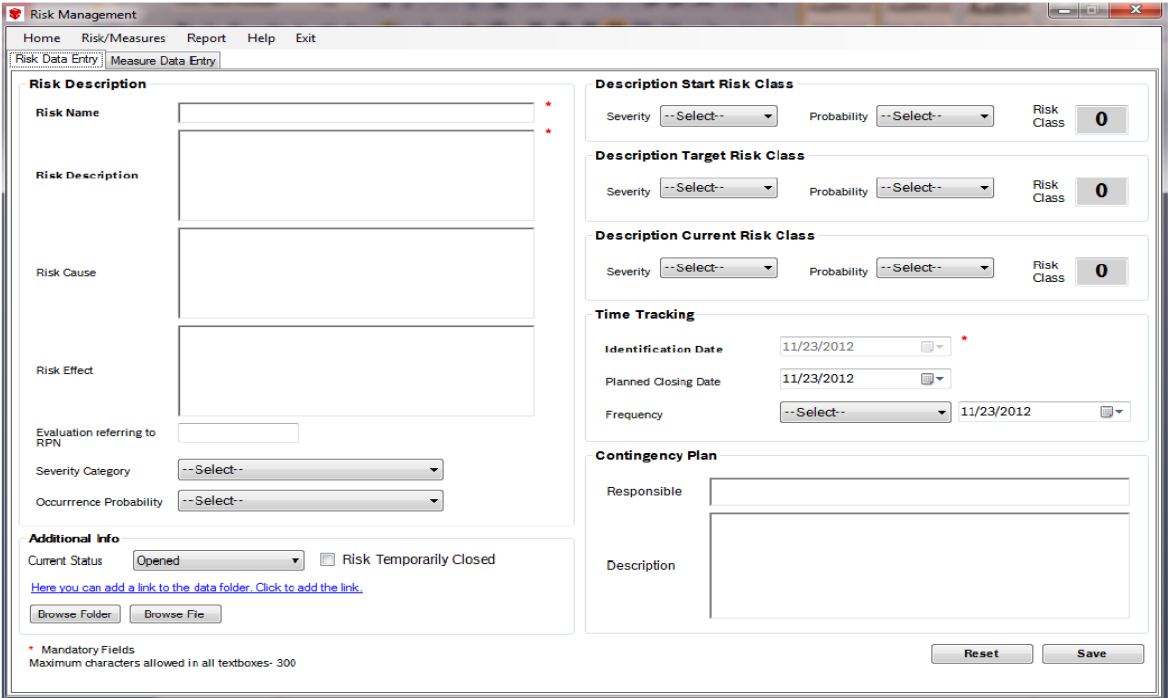


Figure 27 - Risk data entry screen.

On the Risk Description, the user can enter the data for Risk Name, Risk Description, Risk Cause, Risk Effect, Severity Category and Occurrence Probability. Risk Name and Risk Description are mandatory fields. The user can choose the Current status and enter/select a link to the data folder/data file or a

URL on the Additional Info. To close the Risk temporarily, it is necessary to check the checkbox provided for “Risk temporarily closed”.

On the right side, in the Description Start Risk Class (level of risk at the beginning of the project), Description Target Risk Class (acceptable level of risk) and Description Current Risk Class (level of risk to which the project is currently exposed), the manager can enter the severity and probability of the risk. Then, the Start Risk Class, Target Risk Class and Current Risk Class, respectively, will be calculated as per the evaluated severity and probability value.

Concerning Time Tracking, the Identification date is today’s system date by default for new risks. The Planned Closing Date is the estimated closing date of the risk. The Frequency determines the frequency of risk tracking.

Regarding Contingency Plan, it is necessary to enter the Responsible and Description for Contingency Plan.

Finally, the user can save all the entered data by using the ‘Save’ button.

The main limitation of this tool is shown in Figure 28. In the options severity and probability, only the fields “very low”, “low”, “average”, “severe/high” and “very severe/very high” are enabled, not allowing the customisation of the interval for each option.

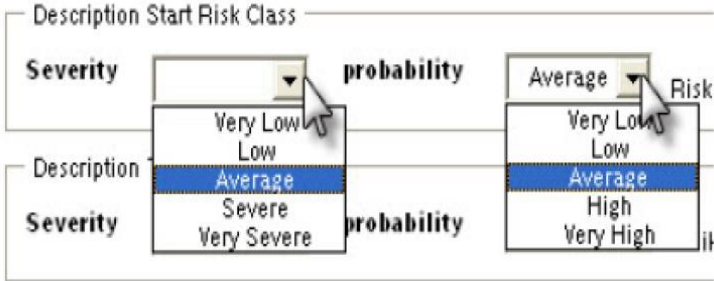


Figure 28 - Risk class.

In the standard established by Bosch, the values established into each category (very low, low, ...) are well-defined. With this tool it is impossible to define these values.

Figure 29 shows the assessment of the probability of occurrence of risk with its significance.

OP factor	Occurrence probability	Remark
Very Low	< 10%	Very low occurrence probability
Low	approx. 30%	Low occurrence probability
Medium	approx. 50%	Medium occurrence probability
High	approx. 70%	High occurrence probability
Very High	> 90%	Very high occurrence probability

Figure 29 - Assessment of risk occurrence probability. (Bosch, 2015c)

There is still a similar table to that presented, but relative to the risk impact assessment, Figure

30.

Impact factor	Criterion			
	Deadline	Specification	Cost risk [in €] ( EWK, PHEK * units)	Q-figures [ppm] based on customer requirement or "CM Roadmap Quality" [4] (the more severe figures apply)
Very Low	RB-internal deadline shift only	a) Minor deviation from the specification, hardly noticeable for the (end) customer, acceptable for (RB) customer (without any further conditions to be fulfilled) b) IT IS UNLIKELY that the failure will have any noticeable effects on the vehicle's behavior. Only allows to be identified by qualified personnel or trained/experienced driver.	< € 50,000	< Factor 1.25
Low	RB-internal deadline shift only	a) Minor deviation from the specification, hardly noticeable for the (end) customer, acceptable for (RB) customer (without any further conditions to be fulfilled) b) THE FAILURE IS INSIGNIFICANT: The customer is bothered to a minor extent only and is likely to experience a minor adverse effect only; observable by an average driver.	€ 50,000 - € 100,000	Factor 1.25 – factor 1.5
Medium	Few important delivery dates shifted only (e.g. of samples) and/or milestones; acceptable for the customer	a) Clear deviation from the specification but likely to be acceptable for (RB) customer (incl. stipulation of further conditions to be fulfilled) b) MEDIUM FAILURE: The customer is bothered to a minor extent only and is likely to experience a minor adverse effect only; observable by an average driver.	€ 100,000 - € 250,000	Factor 1.5 – factor 1.75
High	Deadline shifts of delivery dates (e.g. testing, samples); adverse effects on SOP currently not expected	a) Clear deviation from specification and not acceptable for (RB) customer. b) SEVERE FAILURE: Operational capability of the vehicle strongly impaired, immediate remedy measures by car workshop mandatory.	€ 250,000 - € 500,000	Factor 1.75 – factor 2
Very High	Deadline shifts of important delivery dates (e.g. testing, samples for release) and/or other milestones (e.g. QAs); SOP shifts possible	a) Clear deviation from specification and not acceptable for (RB) customer. b) VERY SEVERE FAILURE: Non-conformity with possibly detrimental effect on vehicle/traffic safety and/or possibly violating statutory provisions, including warning.	>€ 500,000	> Factor 2

Figure 30 - Assessment of risk impact.  
(Bosch, 2015c)

In short, the tool provided by the Diesel System does not allow the customisation and adjustment of the tool to the needs of the section.

When it comes to risk management, it could be said that the section is still in a very low maturity level. This gap is related to lack of knowledge and time to prepare a very detailed and accurate risk analysis.

Another problem identified in the section was that the meetings of risk analysis occur without rigor and accuracy:

- The meetings are not planned on the project schedule (they happen when some team members of the project are available);
- There is no plan for reevaluation of risk analysis;
- Not the whole team is involved in risk analysis; the meetings are always made with the same elements. The team needed to carry out the project is defined in the first meeting in which the project is discussed. For risk analysis, the whole team should be involved, however, risk management was always performed by two elements plus the project manager. This means that the identified risks are always directed to the area where these elements belong, so not all possible risks are covered and evaluated;
- There is no well-defined structure/guidelines to conduct the meeting.





- Roadmap - set of meetings carried out by the senior executives - outputs are projects for CM/MFT3. A project may be from the 2016 roadmap (it was discussed in 2016) and be running in 2017;
- Budget;
- Requester;
- Priority;
- Docupedia;
- Track&Release;
- SharePoint – The SharePoint is a collaborative platform used by the section that allows the creation of a project structure;
- Stakeholder list;
- Project category – CM/MFT3 handles projects of types B or C; this type depends on the categorisation explained on the subchapter 4.3 and have influence on the number of TGs to be performed;
- Project charter;
- Requirement collection - list of requirements provided by all stakeholders;
- Concept study - assessment of project feasibility (e.g. is there technology to execute the project?);
- Cost calculation;
- Target cross - It is a pdf with four questions that should be answered: “what are we striving for?”; “for whom are we doing this?”; “what will our results be?” and “how can we measure our success?”;
- Project organigram - diagram that shows the structure of the project organisation;
- Schedule – schedule for project's milestones, activities, and deliverables;
- Kick-off meeting - creation and approval of the kick-off checklist which consists of the formalisation of the project beginning;
- TGO;
- Concept presentation - state of art and the current status about the technology itself likewise the challenges that the project involves;
- Risk management;
- System validation – the production line modifications' validation and the required production process steps;



- TG2;
- Components purchasing - purchase of materials and components necessary for the execution of the project;
- Machine And Equipment (MAE) - procurement of machines, tools and equipment whenever required by the project;
- TG2a;
- Tryout Methodology – it is a test plan, how will the processability and reliability tests be performed;
- Tryout Results - evaluation of the results obtained after the execution of the planned tests in Tryout Methodology;
- TG3;
- Reliability - If the project requires reliability tests, they have to be performed;
- TG4;
- Handover - is the final phase of the project; it is verified if all documents are completed through a checklist;
- TG5.

The steps are marked as green if they are concluded and it is shown the realisation date; yellow if they are in progress and blank if the steps have not started yet. The exceptions are the columns Docupedia; T&R and SharePoint since they are three computing platforms that open via a direct link.

Having this overview, the separation between projects and activities was facilitated, allowing the projects prioritization, in the column Priority, as shown in Figure 31. The options for priority are: very high; high; medium; low; very low and on hold. This column is fundamental for project management since it allows the work organisation and definition of which tasks are more urgent to perform.

Taking advantage of the tool developed to control the project status, it was concluded that it would be interesting if it was possible to cross projects' and products' activities. For this reason, an extra functionality was added to the base tool. The result of this extra functionality is presented in Figure 32.

The Excel file was created to simplify the cross analysis between projects and products. In parallel, a computerized tool (Track&Release) was used to help in the management of activities scheduling.

Figure 32 presents a double entry table. The projects are listed on the rows of the table, while the products are listed on the columns.

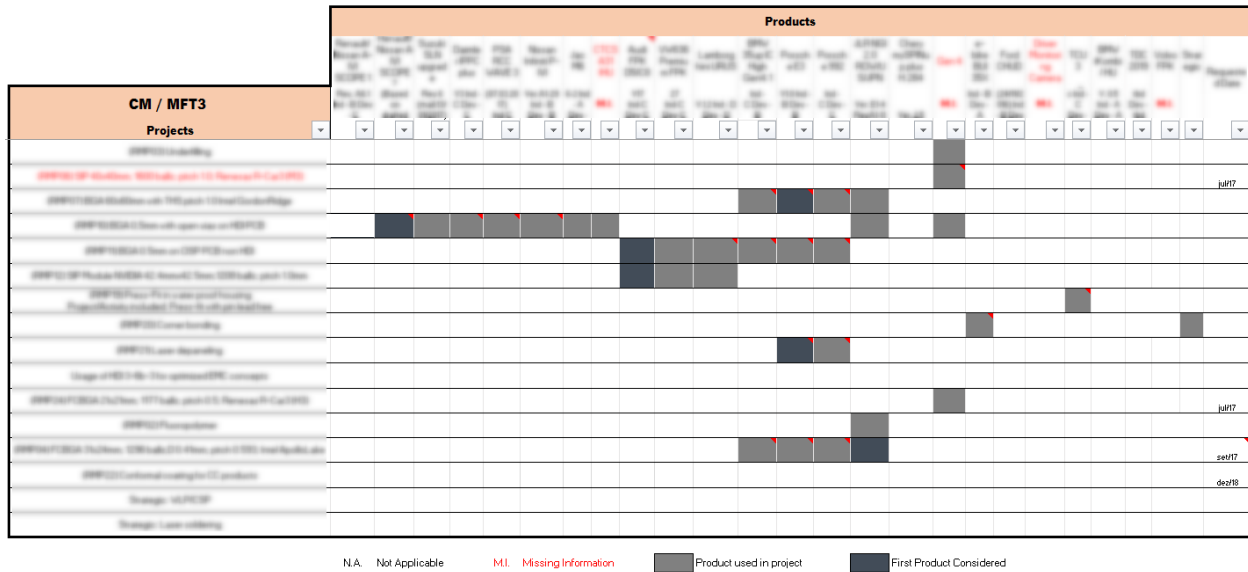


Figure 32 - Cross analysis of projects and products after improvement.

In Figure 32, it is possible to note:

- Light grey colour: the crossing between projects and their products;
- Dark grey colour: when more than one product is associated to a project, the one with the earlier audit is selected first;
- Not Applicable (N.A.): sometimes projects don't have any product associated due to many reasons (could be a strategic project or an innovative project);
- Missing Information (M.I.): when the font colour is red (as it possible see in one project and four products (Figure 32) it means that important information is missing, such as the current schedule.

New information was also added, the products' version, creating the ability to immediately see the version of the product. What happens in the section is that the product schedules often change. Without this improvement, all projects where a product with schedule changes needed to be checked, and then their dates also needed to be changed. Therefore, after implementing this, the effort is reduced, since the product version is verified once.

The cross analysis between projects and products was made possible with this table: the relationship between a project and the products or the relationship between one product and the projects that are influenced by this product. A software tool was used to see the relationship between the projects activities and products over time – Track&Release (subchapter 4.4). Components were created in this tool, which represent projects, and components to symbolise products. The product is created as a component and it is allocated to all the projects in which it is involved, not having to do copy & paste on the repeated lines. Product schedule has to be update only once, since the software searches for the

projects in which this product is associated and automatically updates the schedule of the product on all projects where this (product) has influence. Then filters are created in order to cross analysis between projects and products. With filters, it is possible to call the project/s and the product/s that have interest to be analysed (Figure 33).

In Figure 33, orange blocks correspond to project tasks and blue blocks correspond to product tasks.

The tool Track&Release complements the Excel file (Figure 34). In the Excel file, the project

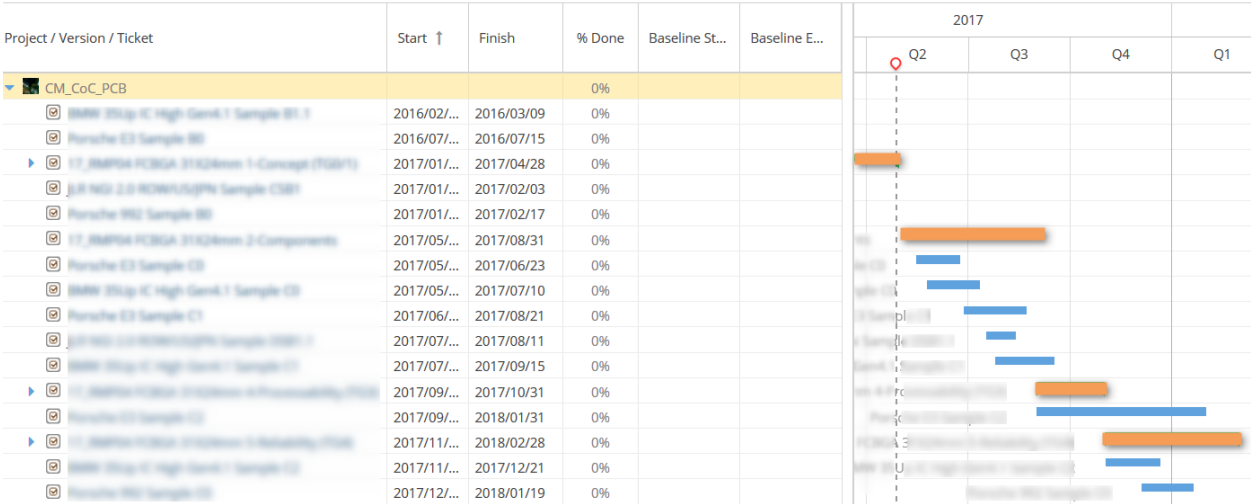


Figure 33 - Cross analysis between project and products over time.

manager sees the relationship between projects and products. For example, the project manager can detect what products influence the project milestones. In T&R, the project manager selects the components that correspond to the project and products (that were identified in the Excel file) that he/she wants to see in the long run.

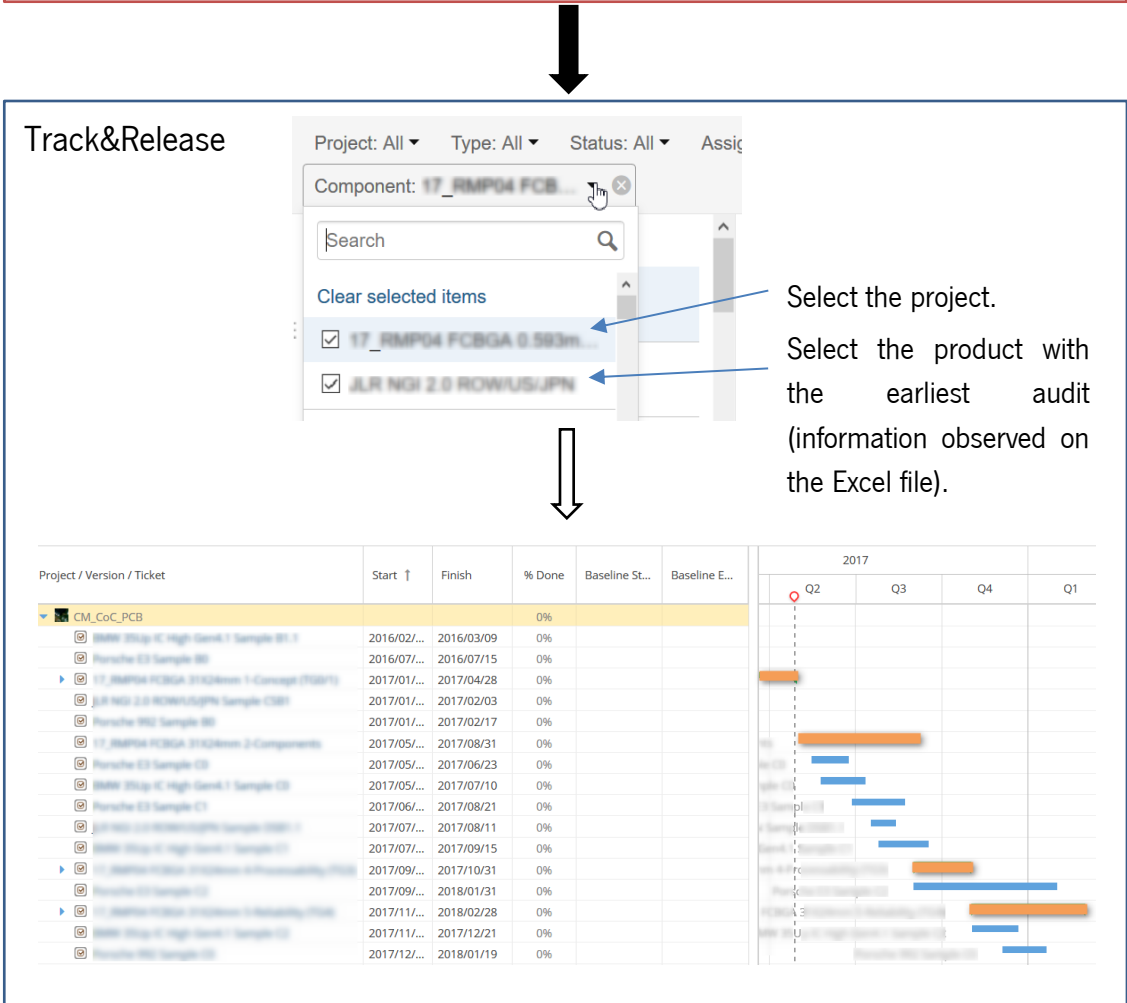
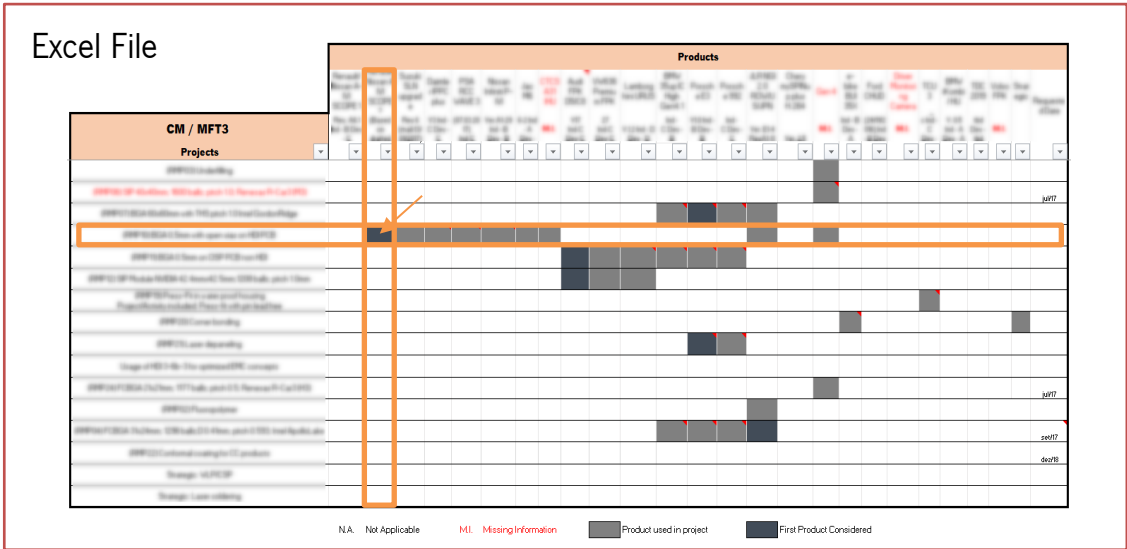


Figure 34 - Relationship between the Excel file and Track&Release.

However, in the old Excel file (Figure 25) the project manager could not see the overlapping of tasks in the projects. The relationships can be seen with this proposal (in terms of schedule) between: all projects, a project and several products, a product and several projects and also between products (although this last possibility is not of great interest).

The new Excel file supports the scheduling of activities and their management. For example, in some cases, by observing the Gantt-Chart, one can see that samples C and D are already being done. This enables the project manager to verify if samples C and D are actually being produced at the right time or if they are late. This possibility of seeing what is or should be happening at the moment was not possible to observe in the Excel file previously used, since that file did not cross the date of the analysis with the dates of the blocks.

As aforementioned, if one project contains more than one product, it is convenient to work with the product that has the first sample earlier. This is another advantage of this method: by consulting the Excel “base”, the project manager sees which products have influence in the project. Then he evaluates which is the most critical product for the fulfilment of the project milestones and if needed he sees only the project with the most critical product. The project management activities focused on only one product (1<sup>st</sup> C-Sample). The product C-Sample is an important milestone for the project, since it is in this sample that the available production line has to be representative for series production.

In order to summarise the impact of this proposal, Table 7 shows the differences between the status of the section before and after the proposal.

Table 7 - Improvement proposal: Tool for the project status control.

Before the proposal	After the proposal
<p>Excel file has several limitations such as:</p> <ul style="list-style-type: none"> <li>• Oversize (when printed it full several A3 pages);</li> <li>• Information overload (usually replicated);</li> <li>• Redundancy of information and errors. A product can impact several projects. In that case, it is necessary to copy-paste the line with product information and paste in all the projects, which the product is involved. It can lead to errors if the users forget to paste the product information in one of the project where the product is including.</li> <li>• Inability to see the overview of the project tasks across time;</li> <li>• Incapacity of crossing project tasks that are attached to a number of products in the long run.</li> </ul>	<ul style="list-style-type: none"> <li>• Easy to filter the desired data. Consequently, the information that appears to the user is reduced in size and complexity.</li> <li>• Elimination of repeated information.</li> <li>• The information of the projects/product is updated once. It is no longer necessary to copy-paste from line to the line of the product, since every time that a product is updated it automatically updates itself in all the projects in which it is involved.</li> <li>• Possibility to follow project task over time. Project manager can see the progress of all the projects.</li> <li>• Ability to see the product tasks related to the project tasks.</li> <li>• Ability to view projects' statuses.</li> </ul>

### 6.2 Tool for the project status overview

The capability to have an overview of projects' statuses is critical for project management. A cockpit chart to assist in project management was developed to fill this gap. More precisely two cockpit charts were developed: one directed at the head of section (Figure 36), since it allows a general overview of the CM/MFT3 status regarding projects, and the other one, seen on Figure 37, more directed at the project manager and the team, since the status of the projects can be visualised in more detail, individually (Figure 36 and Figure 37).

To sustain and help in the creation of these cockpit charts it was necessary the construction of "Mother sheets" (Figure 35). An Excel sheet was created for each constraint that needs to be evaluated: cost, resources, quality and time. Additionally, an Excel sheet to show the status of the tasks related to projects was also created.

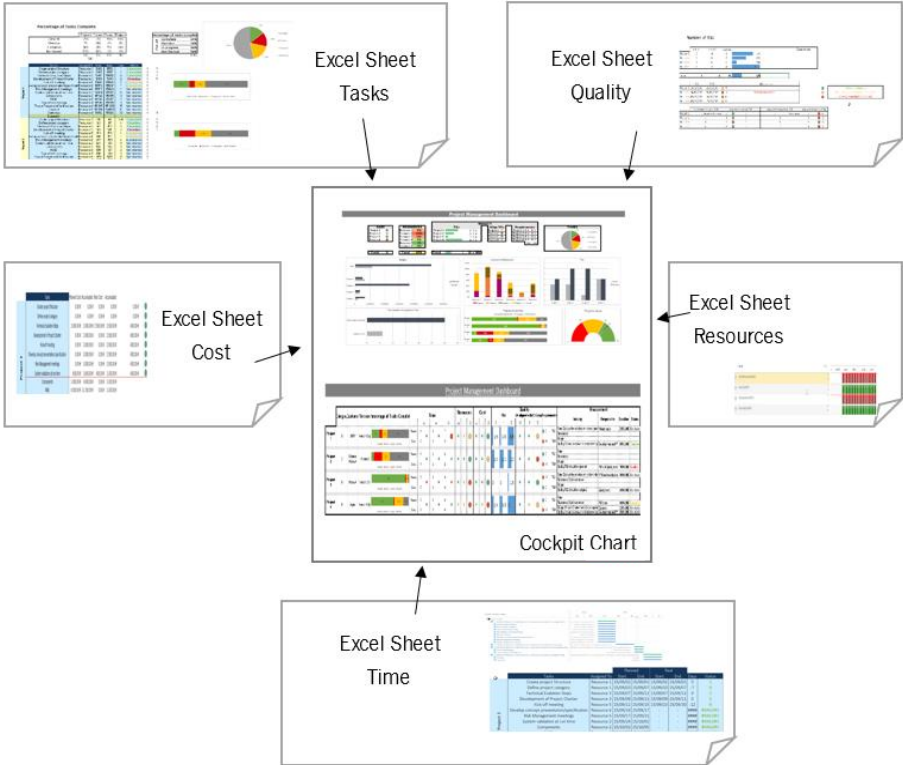


Figure 35 - Cockpit Chart creation process.

Figure 36 presents one of the cockpit charts developed for the project management of the CM/MFT3 section. The figure presented in Appendix 2 brings more detail to Figure 36.

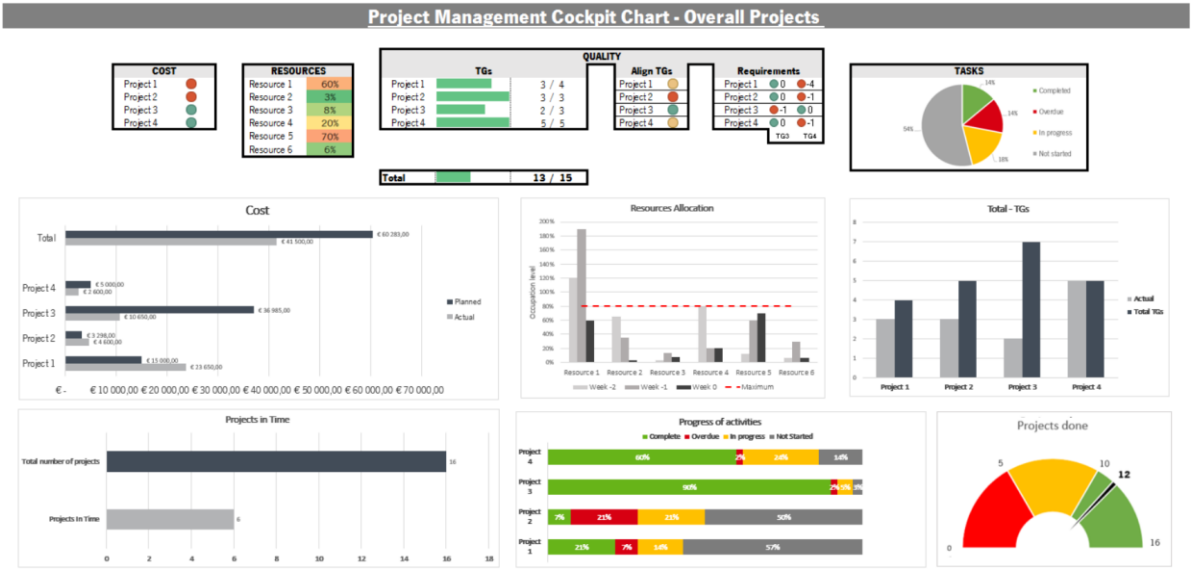


Figure 36 - Cockpit Chart: Projects overall.

The cockpit chart presented in Figure 36 is more oriented towards the head of section and to the top management since on this cockpit chart there is no excessive detail, there is, on the contrary, a very superficial view of the status of CM/MFT3 as regard to projects' management.

On this cockpit chart (Figure 36), a report of the general status of all the projects supervised by CM/MFT3 can be analysed. Four constraints are considered for this cockpit chart: cost, resources, quality and time.

Another cockpit chart was developed (Figure 37), which in fact complements and serves as basis for the previous cockpit chart presented (Figure 36).

**Project Management Cockpit Chart - Individual Projects**

Category	Customer	Version	Tasks	Time	Resources	Cost	TGS	Quality	4 aligned with C-Sam requirement	Measurement					
										Activity	Responsible	Deadline	Status		
Project 1	B	BMW	Version 1.2a	SY	CV	CP	1/4	1/4	3/4	0	TG3	Time: Discuss the schedule with devel	Maintenance	23/03/2017	Not started
				SPI	CV	CP	2/5	2/5	3/5	0	TG3	Resources: Task team force.	PM and stakehold	20/03/2017	Complete
Project 2	C	Daimler Renault	Version 2	SY	CV	CP	2/5	2/5	3/5	0	TG3	Time: Discuss the schedule with stake	PM and stakehold	20/04/2017	Not started
				SPI	CV	CP	0	0	2/3	0	TG4	Quality: TG3 should be realigned.	Quality team.	29/04/2017	Not started
Project 3	B	Renault	Version 2.3	SY	CV	CP	3/5	4/5	5/5	0	TG3	Time: Discuss the schedule with stake	PM team.	20/04/2017	In progress
				SPI	CV	CP	3/5	4/5	5/5	0	TG4	Budget: Project Charter needs to be ree	Diverse	03/05/2017	Not started
Project 4	B	Jaguar	Version 1.8b	SY	CV	CP	3/5	4/5	5/5	0	TG3	Time: Discuss the schedule with stake	PM and stakehold	09/02/2017	Not started
				SPI	CV	CP	3/5	4/5	5/5	0	TG4	Quality: Action to resolve the requireme	Development and	09/02/2017	Not started

Figure 37 - Cockpit Chart: Individual project.

In this cockpit chart (Figure 37) it is possible to examine the individual status reports of all the projects under supervision of CM/MFT3. The purpose of a cockpit chart is to provide information in a format that is both intuitive and insightful. The cockpit charts proposed are an attempt to go to paperless project management and report the most critical information to the stakeholders in the fastest way possible. The figure presented in Appendix 3 brings more detail to Figure 37.

This proposal enables viewers to evaluate exactly how well the project is performing. Each line corresponds to one project. The first column represents the project category (A, B, C or non-project). The

second line describes the customer and the third line is related to product schedule version. The next column presents the situation of the tasks related to the project. The task could be characterised as “completed”, “overdue”, “in progress” or “not started”.

Numbers presented on the heading (-2; -1; 0) represents the weeks, in other words, 0 represents the actual week; -1 represents the last week and -2 two weeks before.

The constraints evaluated are the same in the both cockpit charts. As in the cockpit chart presented previously, the four constraints (time, resources, cost and quality) were also considered in this one. These four constraints are evaluated weekly, and the report presents the current week status and the previous two weeks. It was also added a table, called “Measurement”, which is intended to connect the critical constraints. The measurement considers the action, the responsible, the deadline and the action status: “not started”, “in progress”, “complete” and “overdue”.

Cockpit charts are tools that promote continuously improvement of projects. The next four steps are represented in Figure 38. Performance measures should be turned into data, data should be transformed into knowledge, which in turn leads to improvements being made.

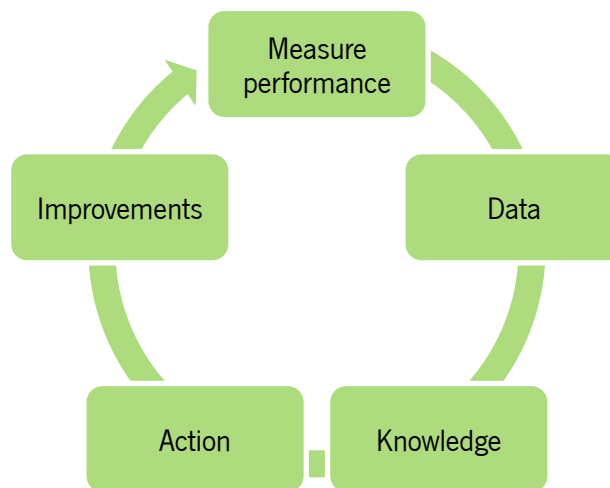


Figure 38 - Cockpit Chart and the continuous improvement.

Projects without appropriate metrics and indicators do not provide suitable information for managers to make the right decisions towards improving their probability of success.

The items that appear in the cockpit charts portrayed in Figure 36 and Figure 37, are elements that both customers and project managers track. These items are referred to as key performance indicators. The key performance indicators used in the cockpit chart and how they were calculated will be presented in the next subchapters.



## 6.2.1 Tasks

In order to represent the main project tasks, 14 blocks were defined. Each task has a designated responsible (field “Assigned To”), a start date, an end date, the duration and the current status. The task status can be “complete”, “overdue”, “in progress” or “not complete” (Figure 39).

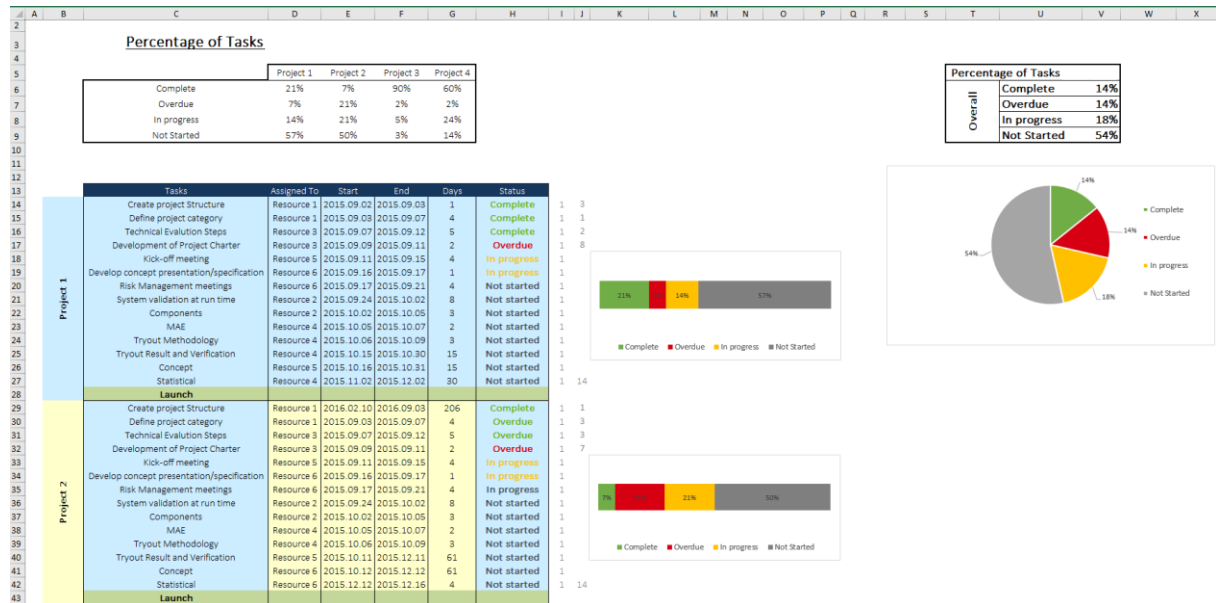


Figure 39 - Excel sheet: Tasks.

When the tasks' status is filled in, a formula counts how many tasks have the status “complete”, “overdue”, “in progress” or “not complete”. The Excel formula used was: SUMIF (range, criteria, [sum\_range]). Observing Project 1, the number of tasks completed is calculated using the following Excel calculation: SUMIF(\$H\$14:\$H\$27;C6;\$I\$14:\$I\$27), which results on 3 tasks completed. The same calculations are repeated for the other status.

After this calculation it is important to know the percentage of completed tasks compared to all the tasks to be performed (Equation 5).

Equation 5 - Percentage of tasks complete.

$$\begin{aligned} \text{Percentage of tasks complete in project 1} &= \frac{\text{Number of tasks complete}}{\text{Total number of tasks}} = \\ &= \frac{\text{SUMIF}(\$H\$14:\$H\$27;C6;\$I\$14:\$I\$27)}{14} = \frac{3}{14} \times 100 = 21\% \end{aligned}$$

The same calculations are repeated for the other statuses. Thus, it can be concluded that 21% of tasks for project 1 are completed, 7% are overdue, 14% are in progress and 57% of activities have not started yet.

Based on these values, a 100% Stacked Bar Chart was introduced to enable an easier distribution of tasks' status. A 100% Stacked Bar Chart as created for each project as can be seen in Figure 39.

At the right side of the Excel sheet it is possible to see the tasks' status for all the projects. Namely, it is possible to note that 14% of all projects' tasks are completed, 14% are overdue, 18% are in progress and 54% of activities have not started yet. In order to complement this information, a pie chart was designed to show the task status distribution as it can be seen in the right-top corner of the Figure 39.

### 6.2.2 Time

A sensitive issue in project management is time control. This constraint consists on the comparison between the planned schedule and the real schedule.

To evaluate the constraint time, the EVM methodology was used. The EVM theoretical part is presented on the subchapter 2.5.

	A	B	C	D	E	F	G	H	I	J
2		<b>Earned Value (EV)</b>								
4		<b>Task Name</b>	<b>TBC</b>	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>
5		Create project Structure	3500	15%	50%	100%	100%	100%	100%	100%
6		Define project category	0							
7		Technical Evaluation Steps	4200		25%	30%	60%	75%	90%	100%
8		Development of Project Charter	4500			25%	40%	50%	100%	100%
9		Kickoff meeting	0							
10		Develop concept presentation/specification	3300					25%	80%	90%
11		Risk Management meetings	0							
12		System validation at run time	0							
13		Components	3000						25%	75%
14		MAE	6700							50%
15		Tryout Methodology	0							
16		Tryout Result and Verification	0							
17		Concept	0							
18		Statistical	0							
20		Earned Value (EV)		525	2800	5885	7820	9725	15170	20770
23		<b>Planned Value (PV)</b>								
25		<b>Task Name</b>	<b>TBC</b>	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>
26		Create project Structure	3500	1000	500	2000				
27		Define project category	0							
28		Technical Evaluation Steps	4200		500	800	900	2000		
29		Development of Project Charter	4500			700	2000	1000	800	
30		Kickoff meeting	0							
31		Develop concept presentation/specification	3300			700	2000	1000	800	
32		Risk Management meetings	0							
33		System validation at run time	0							
34		Components	3000			200	600	1000	1500	
35		MAE	6700					700	500	1000
36		Tryout Methodology	0							
37		Tryout Result and Verification	0							
38		Concept	0							
39		Statistical	0							
41		Total Budgeted Cost	25200	1000	1000	4400	5500	5700	3600	1000
42		Planned Value (PV)		1000	2000	6400	11900	17600	21200	22200
45		<b>Project Performance Metrics</b>		<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>
46		Schedule Variance (SV = EV - PV)		-475	800	-515	-4080	-7875	-6030	-1430
47		Schedule Performance Index (SPI = EV/PV)		0,53	1,40	0,92	0,66	0,55	0,72	0,94

Figure 40 - Excel sheet: Time.

The Excel sheet shown in Figure 40 is the support for the time constraint cockpit chart.

The first table presents the Earned Value (EV) calculations. On the first column, the 14 main tasks mentioned before are listed. On the second column the Total Budgeted Cost (TBC) for each task is presented and then the percentage of work done, in physical terms (what the project has accomplished each week is shown).

The EV (Equation 6) represents the sum of the budget for the activities performed up to now.

Equation 6 - Earned Value (EV).

$$\text{Earned Value} = \sum (\text{Percentage of completed work} \times \text{Total Budgeted Cost (TBC)})$$

The SUMPRODUCT Excel formula was used to transform the Equation 6 into a Excel formula: SUMPRODUCT(D5:D19;\$C\$5:\$C\$19).

In the second table it is presented the Planned Value (PV) which is the approved value of the work to be completed in a given time. This table presents the TBC and the approved value of work to be completed in a week.

The Total Budget Cost is calculated using the SUM Excel formula, more precisely the formula is: SUM(D26:D40) for week 1. The Planned Value (PV) is calculated using the following formula: IF(ISBLANK(E25);NA();SUM(\$D41:E41)), this means that if the cell E25 (week 2) is blank, it should appear #N/A. This is the error value that means "no value is available". If the cell E25 is not empty, the formula makes a cumulative sum up to the week under analysis.

After the Earned Value (EV), Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS) tables are calculated, the Project Performance Metrics are presented (Figure 40). The Schedule Variance (SV) and the Schedule Performance Index (SPI) were calculated based on the two tables.

The formula (Equation 1) used to express SV is project earned value minus the project planned value as of the date of consideration.

Taking for example week2, the SV is equal to 800 (2800-2000). This positive result means that the project is ahead of schedule.

The formula used for SPI is presented in Equation 3. The SPI is determined by dividing EV by PV.

Taking for example week 2, the Excel formula used was =IF(AND(ISBLANK(E22);ISBLANK(E43));"-";E43/E22). The result of the SPI is equal to 1.40. Since SPI is greater than one, this means more work has been completed than the planned work. In other words, the project is ahead of schedule.

In an attempt to go to paperless project management, emphasis is being put to visual displays such as cockpit charts. In the cockpit chart proposed, only simple cockpit chart techniques were used, namely traffic lights to convey critical performance information. Traffic light icons will work as alert icons.

The advantage of the traffic light icon is that it is a widely recognised symbol for communicating a “good state”, “warning state” or “bad state” whereby the colour represents a more or less desirable condition for the KPI.

The conditional formatting of Excel to transform numbers in traffic light icons was used (Figure 41).

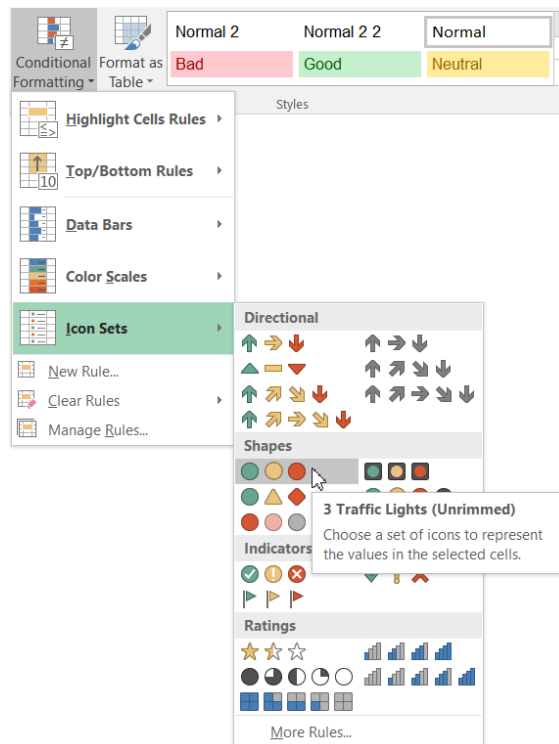


Figure 41 - Conditional formatting - Excel functionality.

Conditional formatting quickly highlights important information in a spreadsheet. To do this, it was necessary to create a conditional formatting rule. The rules are defined below:

- Red
  - SV < 0, if the project is behind schedule, the SV will be negative (i.e. achieved less than what was planned).
  - SPI < 0.9, the project is behind schedule, when SPI is less than one, this fact indicates an unfavourable condition (i.e. achieved less than what was planned).
- Yellow
  - $0,9 \leq SPI < 1$ , the project is late on schedule, but it is not a serious situation (yet).
- Green
  - SV = 0, the project is on schedule.
  - SV > 0, it means that the project is ahead of schedule the SV will be positive (i.e. achieved more than what was planned).
  - SPI = 1, the project is on schedule.

SPI > 1, the project is ahead of schedule, when this value is greater than one, indicates a favorable condition (i.e. achieved more than what planned).

The Figure 42 shows the rules definition for the SPI indicator:

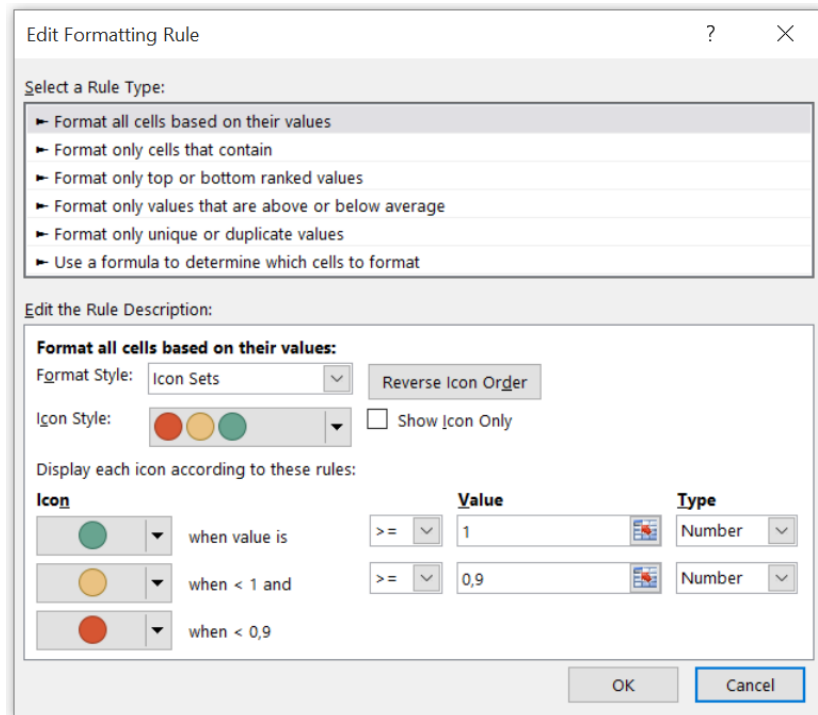


Figure 42 - Rules definition for SPI.

When SPI is less than 0.9 the traffic light that will appear is the red icon. If the value is between 0.9 and 1 the yellow icon appears. If the value of SPI is greater or equal to 1 the green icon will appear.

The output of this labor for time constraint is presented in Figure 43 and in Figure 44.

Figure 43 presents the individual project status regarding time constraint.

		Time		
		-2	-1	0
Project 1	SV	●	●	●
	SPI	●	●	●
Project 2	SV	●	●	●
	SPI	●	●	●
Project 3	SV	●	●	●
	SPI	●	●	●
Project 4	SV	●	●	●
	SPI	●	●	●

Figure 43 - Constraint time on Project Management Cockpit Chart - Individual Projects.

By analysing Project 1 (Figure 43), it is noted that at the moment of analysis the project is behind schedule, since the SV is negative and the SPI is less than 0.9 – red icon for both indicators; in the

previous week the project is ahead schedule ( $SV > 0$ ;  $SPI > 0.9$ ) – green icon; two weeks before the project was late ( $SV < 0$ ;  $SPI < 0.9$ ).

Figure 44 presents the status of all projects from CM/MFT3.

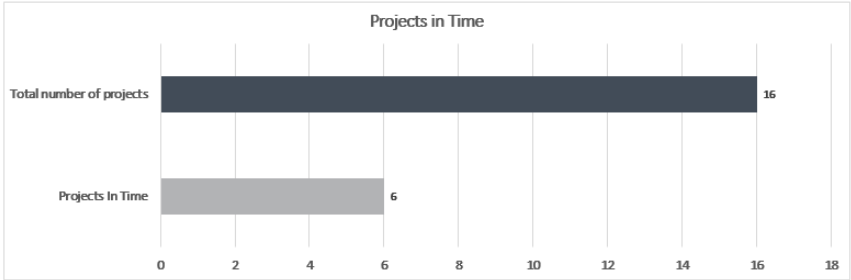


Figure 44 - Constraint time on Project Management Cockpit Chart - Overall Projects.

As mentioned earlier, the number of projects monitored by CM/MFT3 is 16. By observing Figure 44, the manager easily sees that only 6 projects are on time at the moment of evaluation.

The main difference between Figure 43 and Figure 44 is that in Figure 43 the Time constraint is more detailed, project by project, week by week. In Figure 44 the analysis done is another general oversight of the section's status as regarding projects' schedule.

### 6.2.3 Resources

Currently, the section does not use any resource management platform, which makes it too difficult to quantify resource utilisation. With respect to resources management, it is important to allocate resources throughout the weeks (in the cockpit for overall supervision) and the resources' allocation throughout the projects (on the evaluation of the individual status of the projects).

In order to overcome this limitation, Track&Release was used. Once tasks are introduced in this tool, it is simultaneously allocated to one or more resources and the tool automatically describes the allocation of the resources over time (Figure 45).

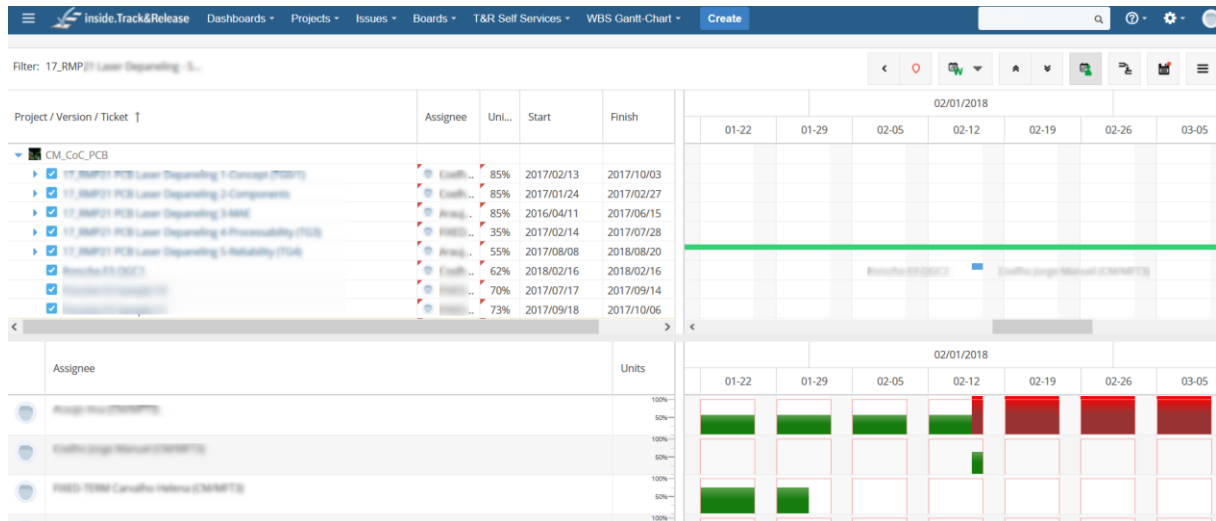


Figure 45 - Resources management on Track&Release (Individual Projects).

In Figure 45 the interface of T&R visible to the project manager in terms of resources allocation is presented. This figure shows one project of CM/MFT3, the person assigned to the tasks, the occupation that this task causes and the start and the finish dates for each task. Then, the T&R automatically create the graphic bar showed in the lower right corner.

Moving the mouse over each block, the information presented in the Figure 46 appeared:

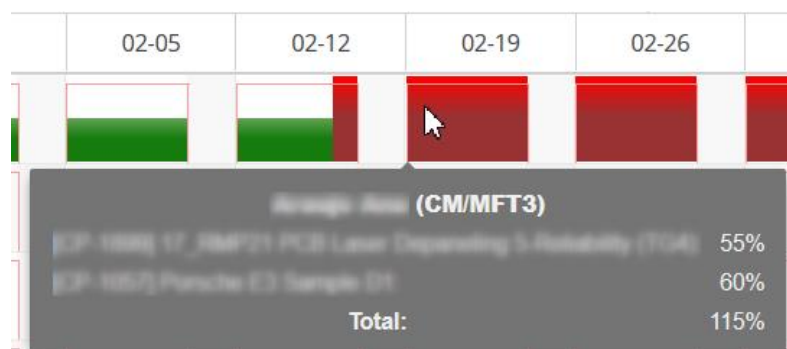


Figure 46 - Resource allocation for a particular week and for a particular project.

With this information, it is possible to determine if the project will have problems concerning resources. It presents the occupation of each resource week by week. By analysing Figure 46, it is possible to conclude that the resource under analysis has two tasks and that the occupation for each one is 55% and 60% respectively, with a total occupation of 115%. This total exceeded the limit for the occupation defined as 80%. This limit was defined with the project manager and the head of section since CM/MFT3 collaborators do not work exclusively for projects.

An Excel sheet with this information to assist resource management was created. The table presented in Figure 47 is based on the data collected from T&R.

	Week 1	Week 2	Week 3	Week 4
Project 1	75%	115%	120%	110%
Project 2	60%	65%	35%	3%
Project 3	30%	3%	13%	8%
Project 4	82%	70%	20%	20%

Figure 47 - Resource allocation in each project by week.

Considering Project 1 analysed on the T&R, there is evidence that after the 2<sup>nd</sup> week the project will have serious problems in terms of resource management as it can be observed in the Figure 46 and in the Figure 47.

The colors shown in Figure 47 were obtained through the conditional formatting of Excel: Red – Yellow - Green Color Scale.

In order to simplify the analysis of these results, three traffic lights were defined in the cockpit chart for individual analysis of the projects. Considering the week 4 the actual week (0), the result is presented in the Figure 48.

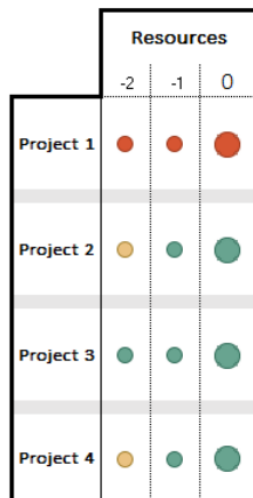


Figure 48 - Traffic lights for resources constraint.

The rules for the traffic lights and for the colors scale are:

- Red  
The resource allocation is greater than 80%.
- Yellow  
The resource allocation is greater than 40% and lower than 80%.
- Green  
The allocation of the resource is less than 40%.



Alongside this analysis, another evaluation needs to be done regarding resource management. In other words, it is necessary to assess the resources' allocation throughout the weeks to present this information on the cockpit for overall supervision.

The steps are the same as the previous ones, however in T&R the tasks of all the projects are analysed.

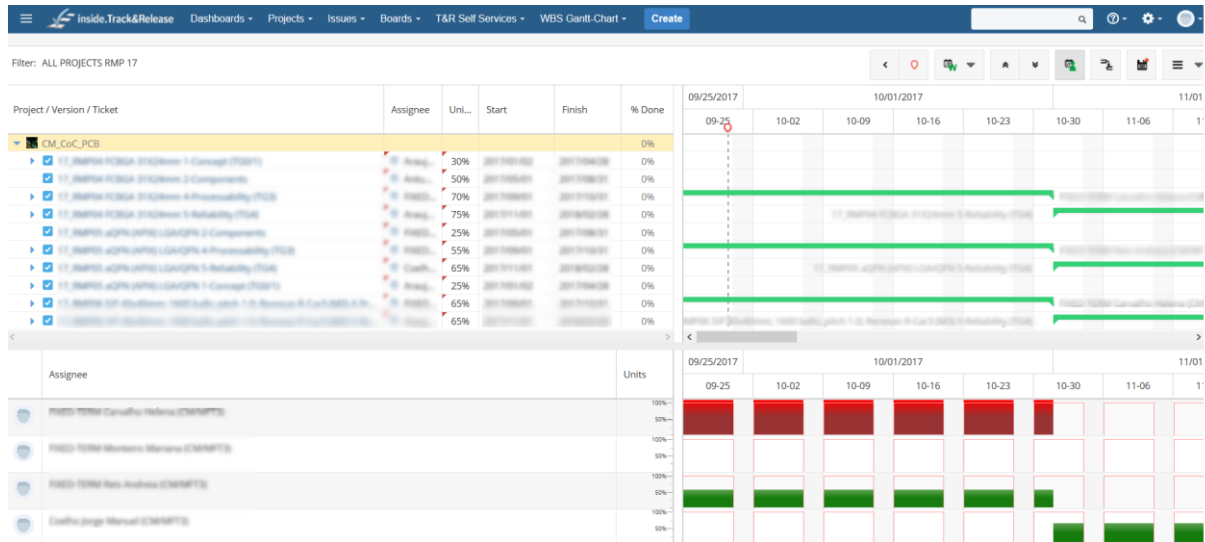


Figure 49 - Resources management on Track&Release (Overall Projects).

Figure 49 shows all projects of CM/MFT3, the person assigned to the task, the occupation that this task causes and the start and the finish dates for each task. Then, the T&R automatically creates the graphic bar showed in the lower right corner. In this graphic it is possible to observe the resources' allocation over the weeks considering all projects.

For example, the first resource (bottom left corner of the Figure 49) is overloaded, moving the mouse over the first red block, the information presented in Figure 50 appears:



Figure 50 - Resource allocation for a particular week.

The occupation of each resource week by week can be determined by this information. By analysing Figure 50, the conclusion is that the resource has three tasks and that the occupation for each one is 70%, 55% and 65% respectively, with a total occupation of 190%. This total exceeded the limit for the occupation defined as 80%.

An Excel sheet was created with this information to assist in resource management (Figure 51).

	Week 1	Week 2	Week 3	Week 4
Resource 1	40%	120%	190%	60%
Resource 2	0%	65%	35%	3%
Resource 3	40%	3%	13%	8%
Resource 4	5%	80%	20%	20%
Resource 5	0%	12%	60%	70%
Resource 6	8%	6%	30%	6%

Figure 51 - Excel sheet: Resources allocation.

With the table presented in Figure 51 the manager quickly sees the resources' occupation.

Only the resources' information for current week is presented in the cockpit chart. In Figure 52, week 4 was selected.

RESOURCES	
Resource 1	60%
Resource 2	3%
Resource 3	8%
Resource 4	20%
Resource 5	70%
Resource 6	6%

Figure 52 - Resources allocation on Project Management Cockpit Chart - Overall Projects.

With this information, the manager easily sees who is the resource more overloaded for the week selected.

Apart from Figure 52, other important graphic was added on the Cockpit Chart - Overall Projects – as seen in Figure 53. In Figure 53, the project manager, the head of section or any other user can easily and quickly see the status of the resources' allocation over the weeks.

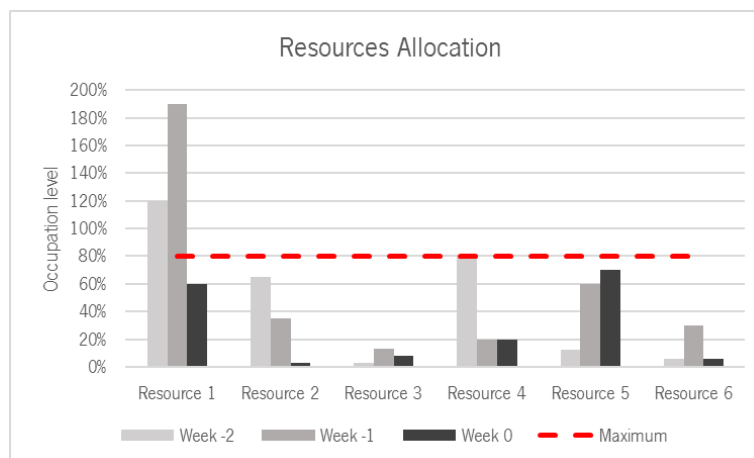


Figure 53 - Resources information on Project Management Cockpit Chart - Overall Projects.

By observing the Figure 53, the current week (week 0) the resource with the greatest level of allocation is resource 5.

#### 6.2.4 Cost

The Earned Value Management was the methodology chosen to support the calculation for the cost constraint. The Earned Value Management theoretical part was presented in the subchapter 2.5.

Just like with the other constraints, an Excel sheet was created (Figure 54) to support the cockpit charts.

	A	B	C	D	E	F	G	H	I	J
2		<b>Actual Cost (AC)</b>								
4		<b>Task Name</b>		<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>
5		Create project Structure		800	250	1500				
6		Define project category								
7		Technical Evaluation Steps			900	700	1200	1700		
8		Development of Project Charter				300	300	1250	1500	
9		Kick-off meeting								
10		Develop concept presentation/specification				300	300	1250	1500	
11		Risk Management meetings								
12		System validation at run time								
13		Components				100	500	900	700	400
14		MAE						400	600	500
15		Tryout Methodology								
16		Tryout Result and Verification								
17		Concept								
18		Statistical								
20		Total Actual Cost		800	1150	2900	2300	5500	4300	900
22		Actual Cost (AC)		800	1950	4850	7150	12650	16950	17850
25		<b>Earned Value (EV)</b>								
27		<b>Task Name</b>	<b>TBC</b>	<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>
28		Create project Structure	3500	15%	50%	100%	100%	100%	100%	100%
29		Define project category	0							
30		Technical Evaluation Steps	4200		25%	30%	60%	75%	90%	100%
31		Development of Project Charter	4500			25%	40%	50%	100%	100%
32		Kick-off meeting	0							
33		Develop concept presentation/specification	3300					25%	80%	90%
34		Risk Management meetings	0							
35		System validation at run time	0							
36		Components	3000						25%	75%
37		MAE	6700							50%
38		Tryout Methodology	0							
39		Tryout Result and Verification	0							
40		Concept	0							
41		Statistical	0							
43		Earned Value (EV)		525	2800	5885	7820	9725	15170	20770
46		<b>Project Performance Metrics</b>		<b>Week 1</b>	<b>Week 2</b>	<b>Week 3</b>	<b>Week 4</b>	<b>Week 5</b>	<b>Week 6</b>	<b>Week 7</b>
47		Cost Variance (CV = EV - AC)		● -275	● 850	● 1035	● 670	● -2925	● -1780	● 2920
48		Cost Performance Index (CPI = EV/AC)		● 0,66	● 1,44	● 1,21	● 1,09	● 0,77	● 0,89	● 1,16

Figure 54 - Excel sheet: Cost.

In this Excel sheet two tables were created, one relative to Actual Cost (AC) and the other one associated to Earned Value (EV). The first table shows the main tasks of the project and the actual cost

per week. Whereas the second table presents the TBC for each task and the percentage of work done per tasks and week. The EV (Equation 6) represents the sum of the budget for the activities performed up to now.

In order to transform the Equation 6 into an Excel formula, the SUMPRODUCT Excel formula was used: (SUMPRODUCT(D28:D42;\$C\$28:\$C\$42)).

After the Actual Cost (AC) and Earned Value (EV) tables, the Project Performance Metrics are presented in Figure 54. The CV and the CPI were calculated based on the two tables. For example, on week 1 the CV is -275, which is the result of the subtraction between 525 and 800 (Equation 7).

Equation 7 - Cost Variance (CV) of week 1.

$$CV_{\text{week 1}} = EV_{\text{week 1}} - AC_{\text{week 1}} = 525 - 800 = -275$$

This result means that the project is over budget. For the percentage of the task that was actually done (15%) it should have been spent 525 and actually it was spent 800 (275 more than supposed).

The CPI helps in the cost efficiency analysis of the project. It measures the value of the work completed compared to the actual cost spent on the project. The CPI, on week 1, is less than one (0.66) which means that the project is earning 0.66 for every 1 spent. In other words, the project is over budget.

In order to make the results of CV and CPI more visual, it was used the conditional formatting of Excel once again. The type of the conditional formatting used was the icon sets, as it can be seen in Figure 54.

The rules for the colours of traffic light are:

- Red

$CV < 0$ , it means that the project is over budget.

$CPI < 0.9$ , the project is over budget. When this value is less than one, indicates an unfavourable condition.

- Yellow

$0.9 \leq CPI < 1$ , the project is over budget, but it is not a serious situation (yet).

- Green

$CV = 0$ , the project is on budget.

$CV > 0$ , it means that the project is within budget.

$CPI = 1$ , the project is on budget.

$CPI > 0.9$ , the project is under budget. When this value is greater than one, indicates a favourable condition.

The output of this cost information is presented in Figure 55 and in Figure 56.

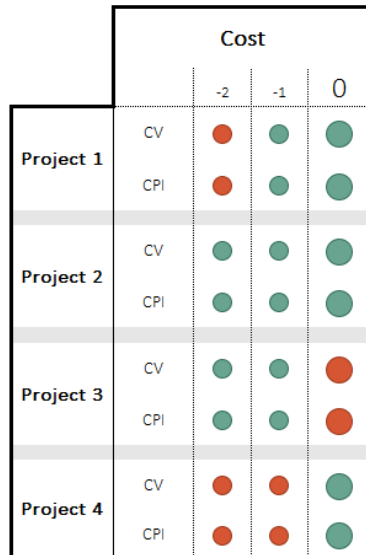


Figure 55 - Cost information on Project Management Cockpit Chart - Individual Projects.

Project 1 is, at the moment of analysis under budget (Figure 55), since CV is positive and the CPI is greater than 1 – green icon for the both indicators; on the previous week the project was under budget (CV>0; CPI>1) – green icon; two weeks before the project was over budget (CV<0; CPI<1).

Figure 56 shows the overall status of the CM/MFT3 projects in terms of cost.

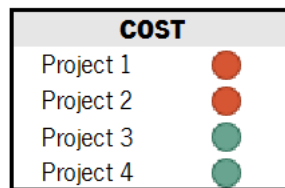


Figure 56 - Cost status on Project Management Cockpit Chart - Overall Projects.

The main difference between Figure 55 and Figure 56 is that in Figure 55 the cost information is more exhaustive, project by project, week by week. In Figure 56 the analysis done is another overall control of the section's status with respect to projects' cost.

Apart from these two figures (Figure 55 and Figure 56), other important graphic was added in the Cockpit Chart - Overall Projects – as seen in Figure 57. Based on the Overall Projects chart, the project manager, the head of section or the team members can easily and quickly see the project status in terms of costs.

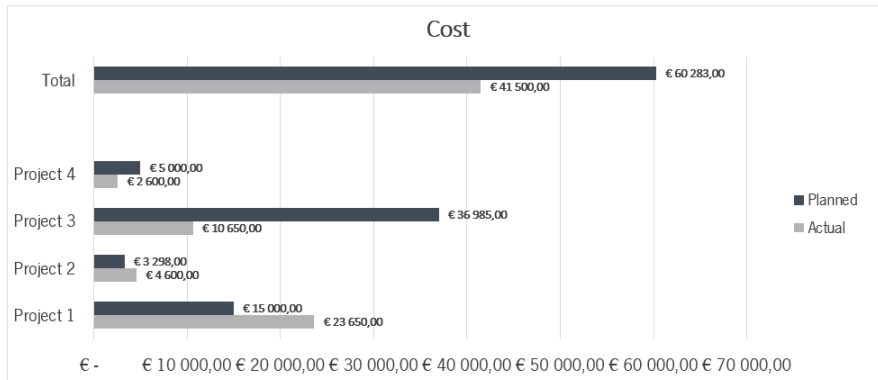


Figure 57 - Cost information on Project Management Cockpit Chart - Overall Projects.

As shown in the chart portrayed in Figure 57, one can see how much is planned to spend throughout the project and how much has been spent till the moment.

### 6.2.5 Quality

The quality is evaluated in three ways, as seen in Figure 58.

	Quality						Requirements
	TGs			TG4 aligned with C-Sample			
	-2	-1	0	-2	-1	0	
Project 1	1/4	1/4	3/4	●	●	●	0 TG3 -4 TG4
Project 2	2/5	2/5	3/5	●	●	●	0 TG3 -1 TG4
Project 3	0	0	2/3	●	●	●	-1 TG3 0 TG4
Project 4	3/5	4/5	5/5	●	●	●	0 TG3 -1 TG4

Figure 58 - Cockpit Chart: Quality constraint.

The first form of assessment is to evaluate the number of TGs made versus the number of TGs planned to be done. Observing Figure 58, in the current week (0), three of the total of four TGs planned for the project have been performed, for project 1. In order to present this assessment, formulas with conditional formatting were used. Using conditional formatting to add data bars to cells with numbers makes it easy to visualise and compare the numbers.

Another way of evaluating project quality involves verifying if the TG4 is aligned with the product C-Sample as described in the standard *PEP-D-I-PD-0003: CM Directive - Production process development* (Figure 16). The alignment between the TG4 and the product C-Sample is a very important milestone since it is on this step that it is evaluated if the production line is adequate for mass production. By observing Figure 58, it is noticed that something is not well (the yellow colour transmits an alert signal).

The project may be getting out of alignment and TG4 would no longer be aligned with the product's C-Sample. The rules defined for traffic light regarding the alignment of TG4 with C-Sample are:

- Red

According to the current information available, TG4 wasn't performed before C-Sample (of the first product considered). If this failure occurs, at least the TG4 should be aligned with QGC2 (Quality Gate Customer).

- Yellow

Based on the project planning, the TG4 will not be aligned with the C-Sample. Nevertheless, actions should be or are already defined in order to reach the TG4 on time.

If the remaining time until the C-Sample is lower than 30 days and the TG4 wasn't performed, the status will be yellow.

- Green

The TG4 is still aligned with the C-Sample.

Observing Figure 58, in TG3 and TG4 occur the evaluation of the requirements' fulfilment (capability requirements, process requirements, legal requirements). Figure 58 shows that the requirements evaluated in TG3 have been met (green colour), however the requirements assessed in TG4 have not been fulfilled (red colour). It is also possible to note that in the TG4 four requirements were not fulfilled. The meaning of the colors of the traffic lights are explained below:

- Red

The requirements for TG3 and TG4 were not met.

- Green

The requirements for the project quality will be met for the interim deliverables (TG3 – processability; TG4 – reliability).

In the Cockpit Chart of all projects, a graphic was added (Figure 59), comparing the total number of TGs to be performed during the project and the actual number of TGs done.

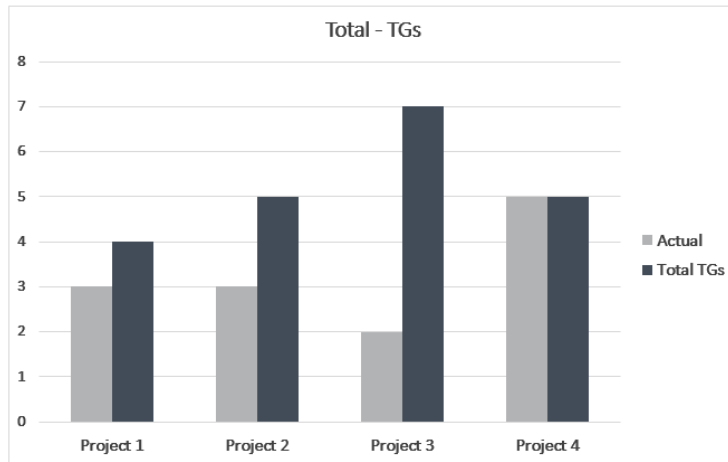


Figure 59 - Total number of TGs by project vs the TGs done.

Having Project 1 as a reference, the conclusion is that 3 out of 4 TGs of the project were done. Project 4, for example, already concluded all the TGs planned.

The main difference between Figure 58 and Figure 59 is that in Figure 58 the purpose is to evaluate the number of TGs made versus the number of TGs planned to be done at the moment. In the graphic presented in Figure 59, the number of TGs done and the total number of TGs to be done until the end of the project are compared. Looking at Project 3, there are two TGs done at the moment of the analysis, the total number of TGs to be done is seven (Figure 59) and the number of TGs that should be done at the moment of the analysis is three (Figure 58).

#### 6.2.6 Other information

Another technique used is a gauge (Figure 60), which is appropriate for dynamic data that can change over time based on variables.



Figure 60 - Gauge example.

Additionally, gauges allow viewers to quickly see how close or how far the team is from a specific threshold. Based on Figure 60, it is noted that the team has sixteen projects to conclude in 2017, and at that moment the project team already concluded twelve projects (black bar).



### 6.2.7 Impact of the proposal

In order to summarise the impact of this proposal, Table 8 shows the differences between the status of the section before and after the implementation of the cockpit charts.

Table 8 - Improvement proposal: Cockpit Chart.

Before the proposal	After the proposal
<ul style="list-style-type: none"> <li>• Impossibility to have an overview of the project status.</li> <li>• Lack of project progress control.</li> </ul>	<p>The benefits of using cockpit chart include:</p> <ul style="list-style-type: none"> <li>• Visual representation of performance measures.</li> <li>• Expertise to identify and correct negative trends.</li> <li>• Capacity to generate reports.</li> <li>• Ability to make decisions more informed based on collect data.</li> <li>• Align strategies and overall goals.</li> <li>• Save time towards running multiple reports.</li> <li>• Increase the transparency of the team objectives, contributing positively to the motivation of the collaborators.</li> </ul>

In order to develop the cockpit charts, it was necessary to define first what information would be advantageous to be presented and how it would be presented. Thus, KPIs and Metrics were defined to measure the project status.

Without the definition of the KPIs and metrics, it was not possible to make a cockpit chart for the section. Table 9 shows the advantages of the definition and implementation of KPIs and Metrics.

Table 9 - Improvement proposal: Metrics for project management.

Before the proposal	After the proposal
<ul style="list-style-type: none"> <li>• Absence of project control.</li> <li>• Decisions based on perceptions due to missing data to support the decisions making.</li> <li>• It is impossible to manage something that is impossible to measure it.</li> <li>• Without quantifying it cannot be controlled, consequently without control</li> </ul>	<ul style="list-style-type: none"> <li>• Metrics and KPIs are the most effective means for alerting project managers since they indicate how much progress was made toward the achievement of the project's targets, goals and objectives.</li> <li>• The benefits of using the metrics presented in the cockpit chart are:             <ul style="list-style-type: none"> <li>• Accurate displaying of project status.</li> </ul> </li> </ul>

<p>is not impossible to guarantee deadlines and objectives.</p>	<ul style="list-style-type: none"> <li>• Early and accurate identification of trends and problems.</li> <li>• A source of critical information for controlling projects.</li> <li>• Metrics show if the projects are hitting the targets/milestones.</li> <li>• Supporting decision-making.</li> </ul>
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Another proposal that was implemented in the section has to do with the fact that there are no rules for the colours that represent the status of things. The most similar to a cockpit chart that CM/MFT3 has ever used was presented in Figure 26: the status colours were attributed inappropriately, and were dependent on the perception of the project manager, and therefore very subjective.

In order to address this situation, some rules and criteria have been elaborated for the assignment of colours to the alerts. These rules were defined together with the people in charge of reading/consulting reports (project managers, project teams).

In order to summarise the impact of this proposal, Table 10 shows the differences between the status of the section before and after the proposal.

Table 10 - Improvement proposal: Traffic lights.

<b>Before the proposal</b>	<b>After the proposal</b>
<ul style="list-style-type: none"> <li>• Absence of platforms for project control.</li> <li>• Lack of rules to define the colours of the constraints' status.</li> </ul>	<ul style="list-style-type: none"> <li>• Evaluation of the current performance of a project in relation to the goal.</li> <li>• Supports project control since there is a standardised procedure.</li> <li>• Simplification of reports.</li> <li>• Standardisation of the evaluation of the constraints.</li> <li>• Clarification of project management rules.</li> <li>• Traffic lights system enables the project manager and the team to identify immediately the risks.</li> </ul>

### 6.3 Risk Management

Regarding risk management, the tool used by the section does not allow its customisation by the standards established by Bosch.

In Bosch, the overall project risk management is described in the standard EWR VA561 *“Risk Management in Projects”*. This risk management considers technical and project risks and should be a part of the project reporting. Protection against technical product risks (function and quality) is ensured through preventive quality assurance measures.

After an analysis of the tool used in the section, a need for change emerged in the way project risks were assessed.

A thorough research was performed: the standards related to risk management and templates for structured risk management developed by Bosch were analysed, along with the approaches used for the consultation of documents and meetings with those responsible for project management. A risk management template was adjusted to meet the standards imposed by Bosch and the needs of the section.

The following figures show the template developed that meets the needs of the section, and which takes into account the norms and standards of Bosch.

A Risk Breakdown Structure (RBS) was created (Figure 61), to help in risk identification. The RBS was elaborated with the project manager and then, it was discussed with the CM/MFT3 collaborators in order to check if the team approve with the RBS defined. The RBS template helps to make sure that all the relevant points are covered, thus working as a “checklist”. During the risk identification stage, the PM works through each of the items and checks those that are applicable to the project.

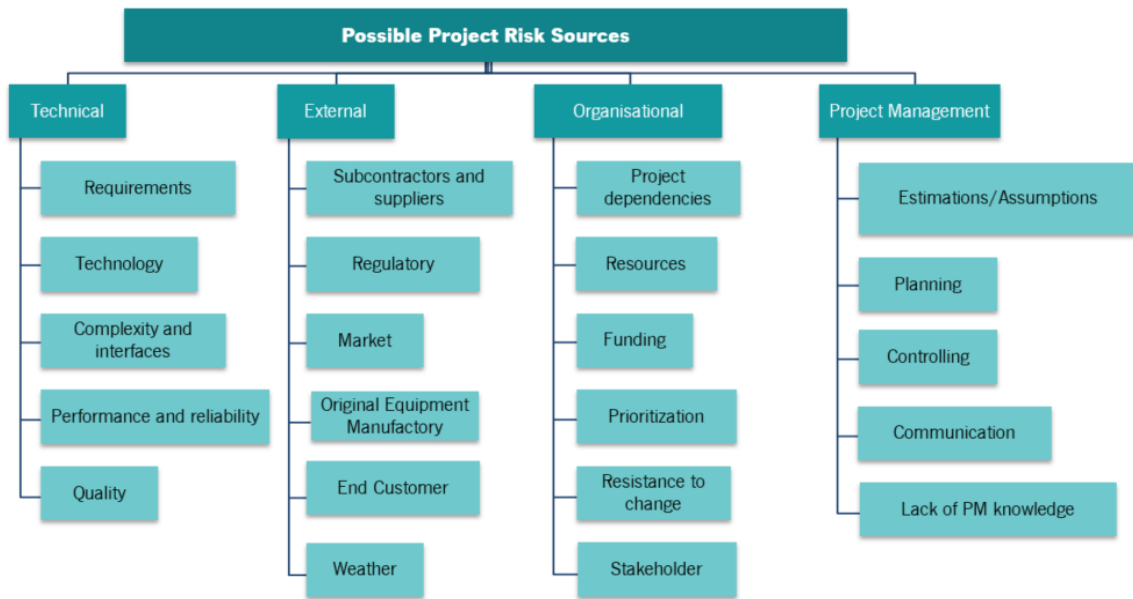


Figure 61 - Risk Breakdown Structure.

The risks are divided into technical risk, external risk, organisational risk or project management risk (Level 1), then subdivided into more specific levels such as the ones presented above (Level 2) and so on.

Technical risk is related to the ability of a technical solution to support/achieve the requirements. Failure to identify or accurately manage these threats results in performance degradation, security breaches and system failures, among others (CAST, 2017). Concerning the requirements, sometimes, these have been discussed and agreed but can change throughout the project. Another situation that can happen is that requirements are poorly defined at the beginning of a project. In an industry that excels in innovation, the technology represents a major risk to projects. Quite often the technology is new and poorly understood by the project team which, as a consequence, may lead to slippage in milestones/targets. There are components, tools or platforms that are difficult to maintain due to their complexity and lack of standard interfaces. In that case, components cannot be scaled to meet performance demands. Quality risks may happen when the deliverable has poor quality, or process inputs are of low quality.

External risks are related to forces such as laws, regulations and markets. For example, a contractor does not deliver components/services as requested by the customer. All the legal and regulatory changes can have impact in the projects. Market changes impact the project (e.g. a market crash). Required hardware could not be delivered as requested and could fail. Customer risk is related to the customer's key success factors for the project. An example of risk associated with customers include

new or changes in requirements and prospects for development speed that developers cannot meet. External events like natural disasters can stop the project.

Potential organisational changes (e.g. restructuring, mergers, acquisitions) should be considered as risks. Dependencies dramatically impact project's constraints (quality, resources, time and budget) (Mar, 2016). Usually, resources availability (internal/external human resources and materials) do not follow initial planning. Risk of delays can happen due to required financial approvals and processes to release funds. Sometimes non-essential activities are prioritised and this fact may influence critical projects schedules (Mar, 2016). Another problem to project management consists in the probability of management considers the project as of lower importance for resources and attention. There is also resistance to change (new tools, leading technologies) that can be considered a risk.

Stakeholders have false expectations: they may believe that the project will fulfil something not found in the requirements list, plans, etc. This may lead to disagreement between stakeholders over project issues.

Often, projects need the same resources at the same time, which can cause enormous problems to their management. An absence of project management should be documented as a risk. All the estimations/assumptions are sources of risks (estimation of costs, schedules, among others). It is important to understand the meaning of these two words. An estimation is a rough calculation of the value, number, quantity, or extent of something (Oxford University, 2017b). An assumption is something that is accepted as true or as certain to happen, without any proof (Oxford University, 2017a). Risks derived from lack or no planning can cause errors in project management processes (such as schedule deviations). Invalid stakeholder expectations or when stakeholders become disengaged (e.g. ignore project communications), can also be a source of risk. Sometimes, communication fails among the project team. The inexperience of the project manager(s) may result in constraints slippages.

Figure 62 shows an example of a risk analysis for a section project.

BOSCH																		
Project: Laser Depaneling																		
Risk Management																		
Last Update:																		
Identification								Initial Analysis			Corrective Action		Current Risk Rating (depends on Status of corrective Action)					
No.	Risk Identification	Customer relevant	Risk-Category	Sub Classification (optional)	Type of risk	Cause of risk	Description of risk	Effect of risk	Probability	Impact	Rating	Mitigation Corrective action	Corrective Action	Probability	Impact	Rating	Remark con. current rating	Top 10 Risks (by Report)
1	17/02/2017	yes	Technical	Requirements	Threat				Low	High	Medium	not needed	---	Low	High	Medium		
2	17/02/2017	yes	Technical	Requirements	Threat				Low	High	Medium	needed		No Risk	No Risk			R10
3	17/02/2017	yes	Technical	Technology	Threat				Low	High	Medium	not needed	---	Low	High	Medium		
4	17/02/2017	yes	Technical	Quality	Threat				Low	Very High	High	not possible	---	Low	Very High	High		
5	17/02/2017	yes	External	End Customer	Threat				Very High	Very High	High	needed		Very High	High	High		R1
6	17/02/2017	no	Technical	Quality	Opportunity				Very High	Very High	High	not possible	---	Very High	Very High	High		R7
7	17/02/2017	no	Technical	Requirements	Threat				Very High	Very High	High	needed		High	Medium	High		R2
8	17/02/2017	yes	Organisational	Resources	Threat				Very High	Very High	High	not possible	---	Very High	Very High	High		R8
9	17/02/2017	yes	Technical	Quality	Threat				Very High	High	High	not needed	---	Very High	High	High		
10	08/03/2017	yes	Technical	Technology	Opportunity				High	Medium	High	needed		Very High	High	High		R4
11	08/03/2017	no	Organisational	Prioritisation	Threat				High	High	High	needed		High	Medium	High		R3
12	08/03/2017	yes	Organisational	Resources	Threat				Very High	Very High	High	not needed	---	Very High	Very High	High		R9
13	08/03/2017	yes	Organisational	Resistance to Change	Threat				Low	Very High	High	needed		Very Low	High	Medium		R5
14	08/03/2017	yes	Project Management	Communication	Threat				Low	High	Medium	needed		Low	Medium	Medium		R6

Figure 62 - Risk analysis of project: Laser Depaneling.

In this template it is necessary to fill in some columns, which are described in Table 11:

Table 11 - Explanation of the fields in template.

<b>Identification</b>	Risk identification date	Date in which the risk identification is made.
	Customer relevance	In this column, the project manager should choose yes / no depending on whether the risk has an effect on the client or not.
	Risk-Category	Based on the RBS prepared, this field defines a category for the risk, whether it is Technical, External Organisational, Project Management or Other.
	Sub Classification	The sub classification is optional; in this column a more specific category of the risk is defined. For example, if the risk is identified as a Technical Risk its category may be Requirements, Technology, Complexity and Interfaces, Performance and Reliability or Quality, as subdivided into RBS.
	Type of risk	A risk could be a threat or an opportunity.
	Cause of risk	In this field, the risks' root causes are described.
	Description of risk	A detailed description of the risks which can affect the project and documents their characteristics.
	Effect of risk	Impact of the risk in the project's objectives.
Probability	Probability of occurrence / Frequency of the event.	

<b>Initial Analysis</b>	Impact	Expected extent of damage.
	Rating	Probability x Impact. Three results are available: High, Medium, Low. Autofill field.
<b>Corrective Action</b>	Mitigation corrective action	Three options are available: needed, not needed, not possible. Depends if a corrective action is necessary, not necessary or not possible.
	Corrective action	In this field, the link (from Track&Release) must be indicated for the action in consideration.
<b>Current Risk Rating</b>	Probability	Probability of occurrence / Frequency of the event.
	Impact	Expected extent of damage.
	Rating	Probability x Impact. Three scale options: High, Medium, Low. Autofill field.
	Remark continuous current rating	Risk management is a continuous activity carried out throughout the life of the project. The developed template takes into account this risk evolution in the projects; in this area the risk assessment is updated, usually every two months or if necessary whenever it is justified. In the case “Current Risk Rating” changes due to external factors that were not planned nor thought in the risk response plan. For example: improvement implemented in a particular machine that reduces the probability of the identified risk to occur.
	Top 10 Risks	Once all risks are identified, the top 10 most critical risks are reported.

After the identification and classification of the risks, the actions plan (Figure 63) is developed.

Response plan (to be included in the schedule)			
Corrective or Preventive	Action	Date	Owner
—	—	—	—
Preventive	Provide support to the business	15/04/2017	Business Unit
—	—	—	—
—	—	—	—
Preventive	Review and update the business plan	02/12/2016	Business Unit
—	—	—	—
Preventive	Review and update the business plan	—	Business Unit
—	—	—	—
—	—	—	—
Corrective	Review of Project Status with the stakeholders for the project	30/03/2017	Business Unit
Corrective	Review and update the business plan	30/03/2017	Business Unit
—	—	—	—
Preventive	Review and update the business plan	30/03/2017	Business Unit
Preventive	Review and update the business plan	30/03/2017	Business Unit

Figure 63 - Response Plan.

In this table, the risk response actions may be preventive (if taken before the risk happens - mitigation plan), or corrective (after the risk happens, to reduce or eliminate it - contingency plan). The actions to be taken should have a responsible member and an implementation date.

After filling the aforementioned information, the template automatically fills the reports that are shown in Figure 64, Figure 65 and Figure 66.

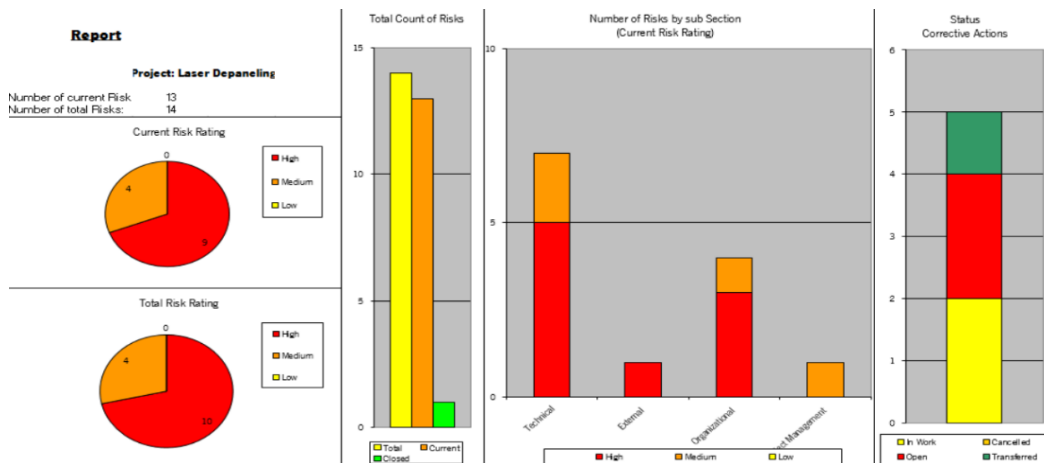


Figure 64 - Distribution of ten selected risks.

Figure 64 presents the distribution of the top ten selected risks. The total count of risks are distributed in current and closed risks, the number of risks by sub section (Technical, External,



Organisational and Project Management) and the status of the corrective actions (in work, open, cancelled or transferred).

The chart shown in Figure 65 portrays the distribution of positive risks, or opportunities. The x-axis represents the probability of occurrence and the y-axis represents the impact.

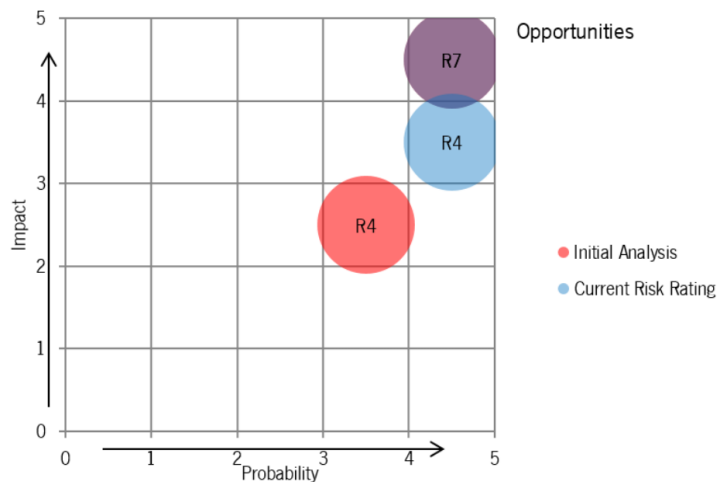


Figure 65 - Risk distribution: opportunities.

Risk four (R4) increased in the probability of occurrence and its impact in relation to the initial analysis. Risk seven (R7) presents the same current risk rating from the initial analysis, it is because of this fact that the bubble of R7 is purple (overlapping of the red colour (initial analysis) and blue (current risk rating)).

The report shown in Figure 66 presents the distribution of negative risks, or threats. The meaning of the axes is the same as previously shown.

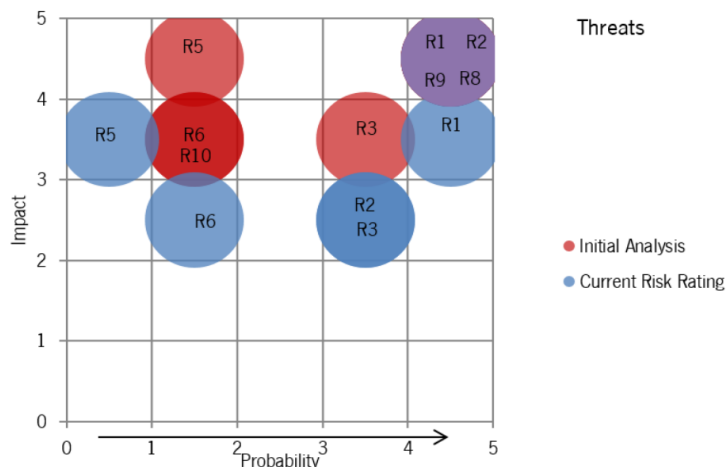


Figure 66 - Risk distribution: threats.

Risks number one (R1), two (R2), three (R3), five (R5) and six (R6) improved their scatter when comparing to the initial analysis. This alteration is very beneficial since that the probability and/or impact were reduced from the initial assessments.

Risk number eight (R8) and nine (R9) didn't change their rating (initial analysis is the same as the current analysis) this is the meaning of purple colour in the Figure 66.

Regarding risk ten (R10) a corrective action was taken, so the report only shows the initial analysis since the risk number ten is no longer considered a risk.

In order to summarise the impact of this proposal, Table 12 shows the differences between the status of the section before and after the proposal.

Table 12 - Improvement proposal: Risk management.

<b>Before the proposal</b>	<b>After the proposal</b>
<ul style="list-style-type: none"> <li>• Risk management standards are not being fully satisfy by section.</li> <li>• The tool provided by the Diesel System does not allow the customisation and adjustment of the tool to the needs of the section.</li> <li>• Risk analysis meetings occurs without rigor and accuracy.</li> </ul>	<ul style="list-style-type: none"> <li>• The risk template is adjusted to meet the standards imposed by Bosch and the needs of the section.</li> <li>• The template developed allows the total customisation and modification to the section needs.</li> <li>• The steps to follow in the risk analysis of a project are well identified. RBS assists in the identification of risks and the tables facilitate the classification of the projects' category. As well as their probability and impact. With this improvement the meetings for the elaboration of the project risks analysis are much more uniform, rigorous and clear.</li> </ul>

## 7. CONCLUSIONS AND FUTURE WORK

The scope of this master's dissertation was associated to the project management, more accurately, it was related with the development of an interface for managing and monitoring projects in an automotive company – Bosch Car Multimedia – at Braga.

The main objective of the company is to create actions to improve performance, standing out, positively, in the market. In order to achieve its objectives successfully, good project management is essential. It is the efficient project management that allows everything to happen in an increasingly shorter time and using less resources. Project management is a key issue in optimizing results.

As a consequence of the increasing number of tasks under CM/MFT3 supervision, existing project management practices have become inappropriate: documents used to plan, control and monitor became obsolete. Thus, the need for the creation of tools for monitoring and control the projects arose.

One of the problems identified in CM/MFT3 was the impossibility of knowing, in real time, in what stage the project was in.

For that reason, an Excel sheet was created where all the team members could see the project progress. In sum, the Excel file has listed all the projects, and columns present the more important steps that the project has to go through until completion. These steps were marked as green if complete, yellow if in progress and no fill if task has yet to be done. With this file, it is possible for the whole team to see at what phase the project is.

For CM/MFT3, it is critical to have an overview of the project status. In order to fill this gap, a cockpit chart to support project management was developed. Firstly, it was necessary to identify which KPIs would be interesting to display on the cockpit chart. After that identification, some of them were selected to be extracted through Track&Release, a tool currently used by the section.

Having this clear objective, the separation between projects and activities was facilitated, allowing the projects' prioritization.

The cockpit chart development has brought numerous advantages to the section, such as:

- Ability to see projects' statuses;
- Visual representation of performance measures;
- Ability to identify and correct negative trends;
- Ability to generate reports;
- Ability to make decisions based on collected data;

- Save time over running multiple reports.

In addition to all these improvements, and since the section is still taking its first steps in project management practices, the mode for undertaking risk management was improved through the creation of a template that respects Bosch standards and that was user-friendly.

Table 13 presents a summary of how the initial objectives have been met.

Table 13 - Relationship between the initial goals and the improvements results.

Objective	Solution
Define and use Key Performance Indicators (KPIs) for project management.	Tool for the project status overview. KPIs were defined to be shown on the cockpit chart.
Extract KPIs through the tool used by the section.	Tool for the project status overview. Some KPIs used in the cockpit chart use information provided by Track&Release.
Develop and implement a tool for the overview of the projects' status.	Tool for the project status control. With this tool it is possible to track and control the projects' progress.
Classify/prioritise projects.	Tool for the project status control. In a simple way all the projects are presented, thus facilitating their prioritisation.
Improvement of the risk management practices in CM/MFT3.	Tool for Risk Management. It was developed a new template for risk management.
Improve PM practice in the section CM/MFT3.	Tool for the project status control. Tool for the project status overview. Tool for Risk Management. With the proposal and implementation of new tools, the project management practices in CM/MFT3 are improved.

Therefore, it can be concluded that all the objectives agreed for this dissertation were successfully achieved.

The difficulties encountered included the changes in CM/MFT3 organisation during the dissertation, and finally the lack of available time from Bosch collaborators.

Project management was not only new for me, but also for the CM/MFT3 section, being considered as another difficulty regarding the reduced experience.

As the future work, the section should continue to improve its knowledge in the various areas of project management. During the development of this master's dissertation it was noticed the dissatisfaction of the stakeholders, which did not feel integrated throughout the projects. The implemented tools (cockpit charts) will contribute to soften this feeling. However, it is necessary to work in the project communications management and project stakeholder management to improve stakeholders' satisfaction.

It is still crucial that the section keeps improving the cockpit chart based on new needs that may arise (new projects, new products or/and new updates). The idea is to be a living document.

The feedback received from CM/MTF3 collaborators was that the difficulties were outlined and the main objective was achieved – it has improved the CM/MFT3 section organisation and project management practices – constituting a master dissertation that has the potential to positively contribute to the performance of CM/MFT3.



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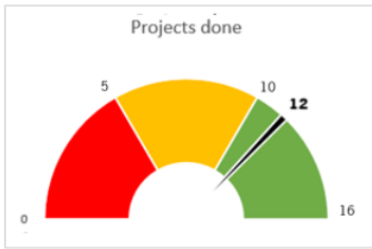
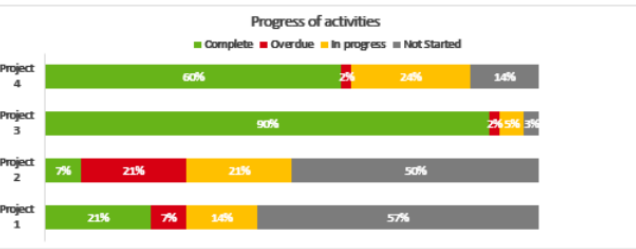
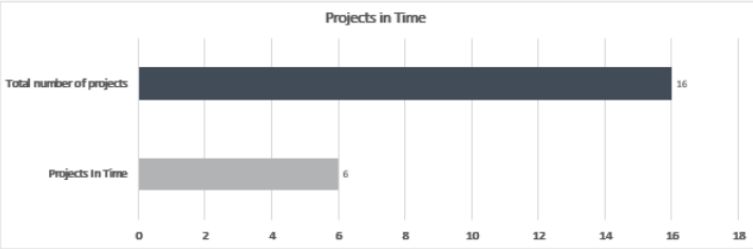
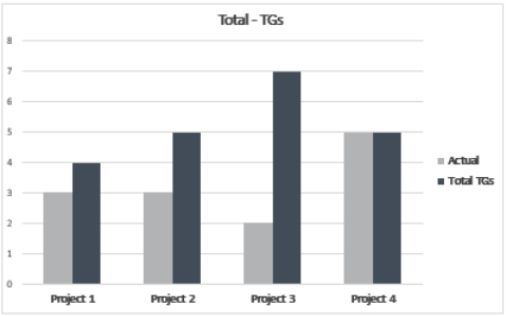
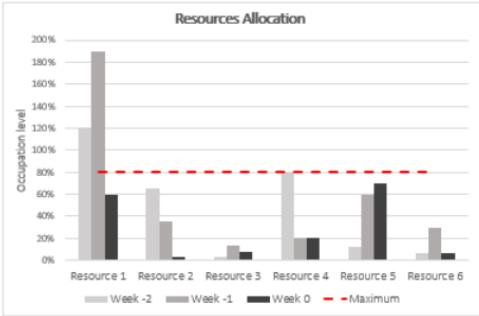
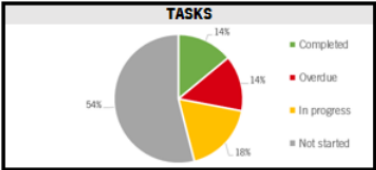
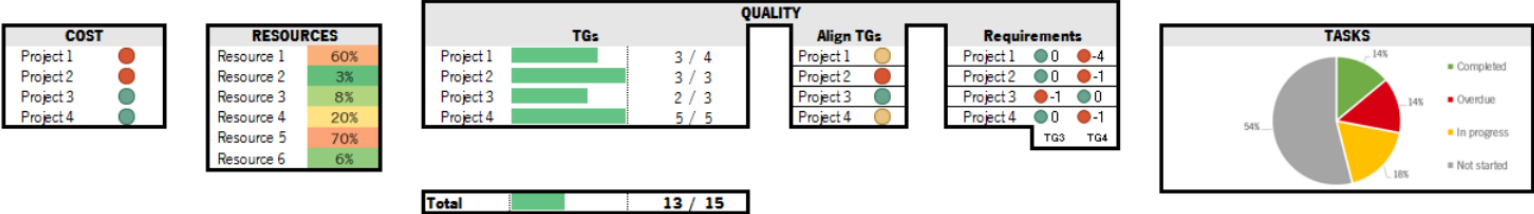
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# APPENDIX 2 –COCKPIT CHART – PROJECTS OVERALL

## Project Management Cockpit Chart - Overall Projects







### APPENDIX 3 –COCKPIT CHART – INDIVIDUAL PROJECTS

Project Management Cockpit Chart - Individual Projects																								
	Category	Customer	Version	Tasks	Time			Resources			Cost			TGs			Quality 4 aligned with C-Sam requirements			Measurement				
					-2	-1	0	-2	-1	0	-2	-1	0	-2	-1	0	-2	-1	0	Activity	Responsible	Deadline	Status	
Project 1	B	BMW	Version 1.2a		SV	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG3	Time: Discuss the schedule with develo	Maintenance	23/03/2017	Not started
					SPI	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG4	Budget:	
Project 2	C	Daimler Renault	Version 2		SV	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG3	Time:			
					SPI	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG4	Budget:	
Project 3	B	Renault	Version 2.3		SV	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG3	Time: Discuss the schedule with stakeh	PM and stakehold	20/04/2017	Not started
					SPI	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG4	Budget: Task team force.	
Project 4	B	Jaguar	Version 1.8b		SV	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG3	Time:			
					SPI	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	TG4	Budget: Project Charter needs to be rea	Diverses.