FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

Process Digitalization Methodology:
A Case Study at EFACEC Service Business Unit

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Resumo

Este projeto divide-se em duas grandes fases, primeiramente o desenvolvimento e aplicação de uma metodologia de transformação digital orientada aos processos de uma unidade de negócio, de seguida, com base no resultado proveniente da etapa anterior, a implementação do seu resultado.

A metodologia de transformação digital desenvolvida durante o projeto visa a identificação de uma nova ferramenta capaz de suportar e otimizar todo, ou parte, do processo em foco. Esta organiza-se em vários passos, inicialmente é necessário fazer um levantamento de alto nível de todos os processos da unidade de negócio e analisar o seu respetivo grau de digitalização, com base em critérios bem delineados e transversais a todos os processos. De acordo com os resultados do primeiro passo seleciona-se o processo que apresenta menor grau de digitalização, que neste caso concreto, foi a gestão de produto. De forma a haver um conhecimento detalhado é necessário refinar o levantamento inicial, através de uma revisão da literatura sobre o mesmo, apurando as melhores práticas para uma reestruturação mais eficaz. Seguidamente, já com o processo bem estruturado, é necessário avaliar os pesos dos seus subprocessos, destacando aqueles que revelam ser mais importantes dos menos importantes, permitindo aferir, numa fase posterior, qual o impacto concreto das várias soluções em análise. De seguida, é feita a avaliação das ferramentas que se enquadram nos critérios de avaliação previamente definidos pela equipa e, finalmente, ocorre uma última avaliação do impacto das ferramentas em cada subprocesso combinando também os pesos das tecnologias com as avaliações dos subprocessos.

Relativamente à segunda fase do projeto, esta consiste na implementação do software resultante da metodologia explicada previamente. Por norma, a implementação pode conter duas fases, o desenvolvimento da ferramenta seguindo metodologias ágeis, caso não seja uma ferramenta adquirida, e a integração na realidade do processo, transversal a todos os casos. No contexto desta dissertação, por se tratar de uma ferramenta adquirida, apenas há lugar para a fase de integração, assim inicialmente é feito um estudo aprofundado sobre o modo de funcionamento da ferramenta e a sua arquitetura. Posteriormente, já com um domínio considerável sobre os recursos desta, é desenvolvido um exemplo concreto sobre um produto da unidade de negócio, demonstrando algumas das capacidades que a ferramenta contempla. Por fim, é possível analisar o impacto de todo o trabalho desenvolvido através de uma nova avaliação do grau tecnológico do processo atualizado.

Palavras-chave: Digitalização de Processos, Gestão do Ciclo de Vida do Produto, Metodologia, Processos de Negócio

Abstract

This dissertation adresses the study of the process digitalization applied to a case study at EFACEC business unit (Service), and is divided into two main phases: first, the development and application of a methodology of digital transformation of processes, then, based on the result of the previous step, the implementation of its outcome.

The digital transformation methodology developed during the project aims to identify a new tool capable of supporting and optimizing all, or part, of the process in focus. It consists of multiple steps, initially it is necessary to perform a high-level mapping of all the processes of the business unit and analyse their respective degree of digitization based on well-defined criteria and transversal to all the processes. Based on the results of the first step, the process with the worst performance is selected, which in this specific case is product management. With the aim to have a detailed knowledge, it is necessary to conduct a literature review about it, determining the best practices for a more efficient redesign of the process. Afterwards, with the process clearly structured, it is necessary to evaluate the weights of its sub-processes, highlighting those that reveal to be more important from those that are less important, allowing the assess, at a later stage, of the solutions impact. Then, the tools that fit the assessment criteria previously defined by the team are evaluated and, finally, a last evaluation of the tools' impact on each sub-process is performed combining also the technologies' weights with the sub-processes' evaluations.

Regarding the second phase of the project, it consists in the implementation of the software resulted from the methodology previously described. In general, the implementation may contain two phases: the development of the tool following agile methodologies, if it is not an acquired software, and the integration in the process reality, which is transversal to all cases. In the context of this dissertation, since it is an acquired tool, there is only space for the integration phase, so initially an exhaustive analysis of the functioning mode of the tool and its architecture is performed. Subsequently, with a considerable domain about the tool features, it is developed a real example about a business unit product, demonstrating some of the capabilities that the tool contemplates. Finally, it is possible to analyse the impact of all the work developed through a new evaluation of the technological level of the updated process.

Keywords: Business Process, Methodology, Process Digitalization, Product Life-cycle Management

"If you can't fly, then run. If you can't run, then walk. If you can't walk, then crawl. But whatever you do, you have to keep moving forward."

Martin Luther King, Jr.

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List of Abbreviations

AHP	Analytic Hierarchy Process
BOM	Bill of Materials
BPMN	Business Process Model and Notation
CMMI	Capability Maturity Model Integration
CAD	Computer-aided design
DSS	Decision Support Systems
DSI	Information Systems Department
DAM	Digital Asset Management
DT	Digital Transformation
ERP	Enterprise Resource Planning
HV	High Voltage
IoT	Internet of Things
LV	Low Voltage
MES	Manufacturing Execution System
Msc	Master of Science
MV	Medium Voltage
MCDA	Multiple-criteria Decision Analysis
PLM	Product Lifecycle Management
SG	Switchgear
SBS	System Breakdown Structure
TRM	Technology roadmap planning
WBS	Work Breakdown Structure

Chapter 1

Introduction

This chapter provides a contextualisation between the work to was performed and the surrounding environment as well as a general idea of the targets.

1.1 Background

This dissertation was developed at the EFACEC Service business unit, which is made up of more than 150 employees with a presence in Portugal and in other countries such as Spain, Angola, Mozambique and Algeria.

EFACEC Power Solutions[1] is a prestigious Portuguese brand with 70 years, the company currently has an international presence in over 65 countries, thus assuming a clearly exporter profile. EFACEC is a company that provides solutions for a sustainable world in the new Era of Energy, as referred in the company's slogan present in Image 1.1. Its mission is to distribute value with Energy, Environmental and Transportation solutions that improve our everyday life, through the integration of different skills and the most innovative technologies. Therefore, the enterprise values are firmly rooted in the focus on success of all clients, on efficiency as a mean to maximise competitiveness and, at last, on adaptability to deliver excellence [1].

In particular, the Service Business Unit seeks to ensure adequate solutions to customers' needs in Industrial facilities, hydroelectric, thermoelectric plants, thermoelectric power plants, small hydro power plants, wind farms, substations and transformation stations. Furthermore, every provided services have the highest quality standards, certified according to ISO 9001: 2008, ISO 14001:2004 and OHAS 18001:2007. Hence, this unit is responsible for inspection, testing, diagnostics, maintenance, repair and commissioning of work in AC and DC Motors, alternators, distribution and power transformers, transformation stations, Protection Relays and others [6].

Looking now at the structure of the department, which is highly important to understand for the development of this project. Its structure ensures the commercial, technological and operational vision across 's global organization. Being divided into four business areas: Physical Asset

[1] https://www.efacec.pt/

Management, Digital Asset Management, Upcycling & Recycling and Integrated Solutions. Besides that, there are support areas that provide backup for all processes, such as Industrial Engineer & Lean, Quality, Administrative support and Operational Control. It is worth noting that the commercial vision is subdivided into Sales, Proposals and Backoffice, the technology in R&D, Product Engineering and Product Management. Finally, operational sight is categorised in planning, logistics, production, final testing, O&M and project management.

Sequently, in each department there are several processes which are executed every day. Those procedures are often unoptimised and have a basic degree of digitization causing delays, failures and, in some cases, low motivation levels within the team. With the purpose of handle this, it is proposed to apply a methodology for the inclusion of technologies in the existing processes, bearing in mind several previous studies.

Those investigations suggest that technology is responsible for the transformation of the way businesses operate, such as in their control, connection with stakeholders or interaction with customers [7]. Therefore, digitization has changed client expectations and behaviour leading the business reinvention with the aim to create and preserve the market demand. Nowadays, the companies cannot simply satisfy the demand, they have to be capable of anticipating it and forecasting the market requirements even before it is perceived [8].

Figure 1.1: EFACEC logotype. Adaptaded from [1]

1.2 Motivation

In the past, the industrial revolution was focused on the automation of mass production. Nowadays we are also facing an industrial revolution, however based on a digital context. The focus remains on mass production, yet based on other pillars including flexibility, adaptability and customisation. Organisations are therefore under a serious threat either to their economy and to their sustainability, they are "obliged" to put aside traditional business models and convert to Digital

Transformation (DT). This is an era in which digitization is increasingly present in social innovation. It is essential that companies keep up with all new trends in order to boost the rapid evolution cost savings and sustainability [9].

With the rapid advance of information technologies, business dynamics contemplate phenomena such as Internet of things (IoT), cyber physical systems, machine learning, among others. All these factors create new opportunities and new challenges for companies, leading to the creation of new ways of delivering services, developing products, etc. Thus, for companies to be able to keep up with the market requirements, it is crucial that there is a strong focus on DT. Therefore, there is a shift from traditional methods of creation and delivery of value, including both operational procedures and product characteristics [10, 11].

DT is unique, since it is able to join the user experience to the industry, which in the past were separated allowing the creation of value. A great advantage is also the reprogramming capacity that it has, and thus can be constantly changed and, consequently, optimized or adapted to new adversities. These features are extremely important to any company, due to the impact caused on the internal structure.

It is clear that a DT methodology is very important and useful for any business area, as it is possible to understand several factors such as the current position of the company in this particular subject, which processes are less developed and also which are the best solutions to support these same processes with the aim of optimising them through digitalization.

To conclude, DT is not only the application of IT, but also process redesign, automation and optimization with the purpose of making the product user-friendly, cheaper, efficient and faster. For the methodology to be executed in a proper and effective way it is fundamental that its actors have knowledge in the IT area but also in the areas of process modeling, optimization and automation [12], without expertise in these different areas the final result will not be as powerful as desired since there is a great interdependence between the areas mentioned.

1.3 Objectives

This project can be divided into two crucial parts, each one with its own objectives. The first relates to the design of a methodology that allows the user to map the department and its process details towards its digitization, operating as a trigger to the second phase, which in turn is the implementation of the resulting technology in the enterprise environment.

On the one hand, the first part has as its primary purpose the dematerializing and optimizing of core processes. In this regard, due to its application, it will firstly be possible to understand the structure and the *modus operandi* of the key processes of the business unit, assigning a degree of technology to each one, based on the tools that are being used by the different actors. Next, the process with the highest level of necessity for improvement is chosen. It is studied and redesigned in order to optimise it and then there is a selection of a suitable technology for the business environment according to strict evaluation criteria. Thus, it is possible to conclude that the final

output of the methodology will contribute to the success of the primary objective previously mentioned, dematerializing and optimizing of core processes. It is also worth noting that the literature review in this part will be essential for the success of the project, since it will allow not only a contextualisation with the process necessities, but also its adjustment to business reality.

On the other hand, the second phase aims at implementing the technology elected in the previous stage. This implementation may consist in the development of the tool and its subsequent application to the real case or only in the last part, since it could be an acquired tool or one already present in the business environment. It is important to note that in the latter case some development may also be required if the software is open source. Regarding the development phase, if applicable, the primary objective is to ensure compliance with all functional and non-functional requirements, ensuring that the tool is able to support and optimise the part of the process of interest. Concerning the application to the real case, it is a necessary step in any of the cases, since it is necessary to introduce all the necessary information and promote its use during the process execution. As throughout the methodology the process analysis is about high levels, which means that there is no extensive detail, it might not be necessary to redesign at these stages and only at the lower levels, in other words, layers more detailed. Finally, at the conclusion of its implementation, there should be a considerable improvement in the digitalisation degree of the process, confirming the success of the methodology.

1.4 Dissertation Structure

This document is divided into four chapters. The first Chapter 1 focuses on a contextualization of the work to be developed throughout the project, from the background, motivation, objective and structure of the dissertation, allowing the reader a preliminary contact with the reality where the project will be developed as well as the most important information about the connection of objectives and motivations with the different project stages.

Chapter 2 concentrates on the analysis of DT, from the concept, to methods that lead to its implementation and the problems that emerge from this approach, which allow a contextualization with the real world according to the perspective of several authors. Thus, it is possible to aggregate several DT approaches in order to obtain an appropriate configuration to achieve the proposed objectives. Furthermore, in this chapter it is also possible to compare various agile methodologies with the aim of implementing the tool. It becomes an added value for the organisation and consequent success of the project.

It is also worth mentioning that a bibliographical review of both the process in focus and the selected tool will be necessary in the future, however, they will be presented in Chapter 3 and Chapter 4, respectively.

The Chapter 3 consists in the application, in a real context, of the methodology previously studied. Here we will be able to see, in a practical way, how the steps were followed and what results it is possible to achieve. To put it in another way, at the end of this chapter, the reader will be capable of understanding how the steps were accomplished, which criteria were followed and

why, and how they are applicable to the business reality. To conclude, it is possible to understand the interconnection and sequence between the different phases of the evaluation process, as well as the reason for their dependency, for instance, it is possible to understand the connections between the successive phases and to understand why it is not possible to leap steps or rearrange the order of them. The output of this chapter is the software that will be implemented to support the process.

In the Chapter 4, with the tool to be implemented already identified, we proceed to its profound analysis phase, to fully understand all its features and benefits, this analysis ranges from its organisational architecture to the different functionalities offered. With this knowledge acquired, the next step is integration with a concrete example relating to a product and its integration with the several levels.

Finally, Chapter 5 presents the conclusions regarding all the work developed during the project, as well as future work, to put it simply, what steps should be executed with the purpose to ensure the continuation of the project.

Chapter 2

Bibliographical review

In order to understand the problem that we are facing, how it is framed in current society and how we can cope with it, it is important to conduct a detailed research covering all the concepts to be explored.

The fact that we are aware of how the problem is positioned in the industrial reality is crucial to adopt the strategies which better match it, without this perception the mistakes which may arise will be considerably more common and harder to solve.

Furthermore, it allows us to confront the strategies adopted in different scenarios, providing us with the possibility of identifying the one that not only obtains the best results but also the one that best suits our case. It also provides an opportunity to combine the strengths of different approaches, resulting in highly interesting new methodologies.

However, it is important to bear in mind that the methodologies found will necessarily have to be adapted to industrial reality.

2.1 Digital Transformation

2.1.1 Problem description

DT has a fundamental role in society, with greater emphasis on the economy. The fact that technology can easily adapt to external adversities makes it a tool with a wide scope [13, 14]. This phenomenon has a disruptive character leading to profound changes in business models and practices. Companies need to establish transformation models in order to manage and monitor their results. Thus, the strategy to be used must be aligned with the concept to be implemented, in such a way that the impact caused on the final result is the most profitable for the organization [15].

Despite its advantages, the number of companies that actually implement such transformations is substantially low, since it can present costs that are relatively high and difficult to afford. A study in Russia shows that 55% of industrial companies do not spend more than 1% of their enterprise budget on digitization and IT infrastructure [16]. An additional reason for these figures is the absence of a transversal definition of several aspects inherent to this thematic, such as an explicit

definition for the digital transformation of business models, a methodology to implement it and which steps and tools might be considered. [13]

To conclude, it is necessary to elaborate a structured framework that allows either the evaluation of the current digital capacity or to establish a strategic plan to implement a technology to optimize processes. Which will bring the growth of opportunities in new markets (46,0%) and the increase of competitive pressure (54,2%), according to a study in 2017 [17, 18].

2.1.2 Problem definition

DT can be applied in several types of technologies, from mobile, analytics, cloud, IoT, among others. In order to be applied successfully it is necessary to consider at least three aspects: the impact from the customer's point of view, the impact on the objectives of the company and its structure and, finally, the impact from a generalized point that is often responsible for deep changes in the business model [13].

In short, to establish an effective DT it is not sufficient to follow a framework, it is necessary to adjust it to the context in which we are operating [13]. Thus, in general, it will be necessary to begin with a high-level mapping of the main departments' processes in terms of having a global vision of the company. In a second stage, select and model a business process, establish proper technologies, evaluate them from multiple perspectives considering their weight in the business process, final evaluation and categorize the results [14].

Furthermore, at a posterior stage and considering some factors, such as the results obtained previously and EFACEC's availability, there will be space for the implementation of the chosen technology. Hence, a new research focused on what we intend to implement will be required.

2.1.3 Problem solution

After contextualizing with the problem identified throughout this chapter, it is necessary to consider several methodologies concerning different themes, including modelling, evaluation, research and implementation. To this end, it was essential to investigate several articles referring to studies performed in this context, as a mean to obtain a consistent work framed with the reality of actual society.

Afterwards, the analysis of the investigations and EFACEC's requirements and interests it was possible to identify methodologies that have resulted in a planning to be conducted during this project.

First of all, it initiates with a survey of the fundamental activities of the company allowing a high level visualization, not only of its structural organization, but also of the way it is executing its operations. For this purpose, the bizagi program seems to be the most suitable as it permits the use of the BPMN language, important for modeling both at high and low levels as we will subsequently verify. Furthermore, in accordance with the requirements of EFACEC, it will be necessary to hierarchy the processes according to their degree of digitization. For this purpose there are several types of approaches, such as a four-tier matrix where the level of digitization and

its preponderance in the company can be defined, as shown in Figure 2.1. To fill out the matrix it is important to have a structural and temporal vision about the execution of the processes, with the purpose of understanding which weaknesses exist and how to mitigate them. With this purpose it' s necessary to analyze with the actors involved since it is very important to take into consideration both their pains and suggestions regarding the processes they execute every day, thus allowing their inclusion in the transformation process and consequently closer results to reality.

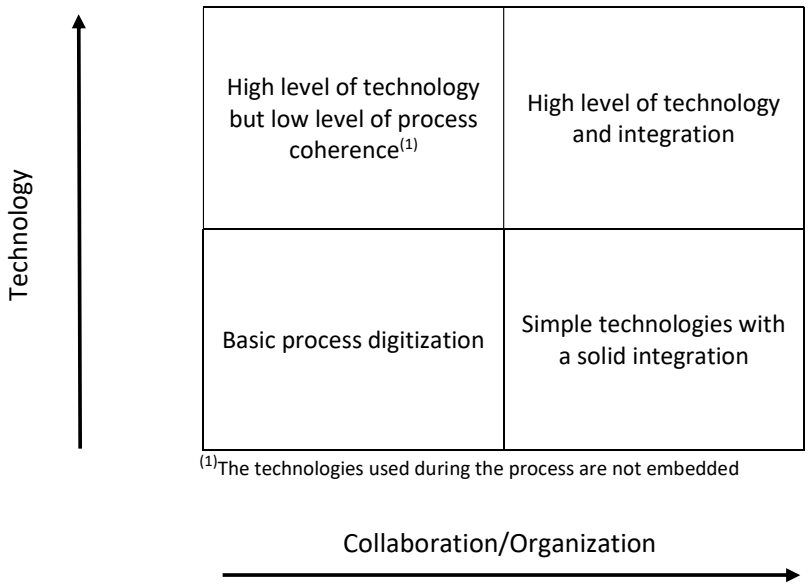

Figure 2.1: Matrix of Digitization Degree [2]

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These four dimensions will have to be adapted in comparison with the existing frameworks to fit in with EFACEC's ambitions. Thus, we notice that they will have to comply with both the technology and the organisation [2].

After selecting the process of interest, using the matrix referred above, it is necessary to make a new process model, however in a deeper way, in other words, identifying its relevant sub processes, the relationships they establish between themselves and the main actors. According to the literature the identification of sub-processes is sufficient [14], however during the execution of the project it might be necessary to explore further with the aim of identify applicable technologies more accurately. Therefore, we will have to identify the relative importance of each sub-process in the context of the process in focus, which will allow us to have an analytical knowledge of the preponderance of the different phases involved in the process, thereby we will adopt the Multiple-criteria decision analysis (MCDA) methodology resulting in values of relative importance for each sub-process, as in Table 2.1. To construct the matrix we will use the Analytic Hierarchy Process (AHP) scale with the scale explained in Figure 2.2.

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Essential importance	Experience and judgement strongly favour one activity over another
7	Very strong importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	When compromise is needed between two

Figure 2.2: AHP scale [3].

	SP1	SP2	SP3	SP4	Weight
SP1	1	3	3	3	0,5
SP2	1/3	1	1	1	0,17
SP3	1/3	1	1	1	0,17
SP4	1/3	1	1	1	0,17

Table 2.1: Sub-processes weights matrix, with AHP scale.

Following, is necessary to introduce the technology concept into this project. To this end, initially and with a solid knowledge of the process it is mandatory to establish evaluation criteria in order to facilitate the technologies assessment, these criteria will have to be discussed and agreed with EFACEC with the aim of making their use viable for investigation, since they will also have to contemplate certain functional and non-functional requirements of the enterprise. It should be noted that the fact that these criteria are currently being developed will be quite useful, since it will also allow a more appropriate framework for the technologies under consideration, in other words this step provides a background on what the technologies will have to cover, simplifying the task of seeking them.

After the previous step, a pre-selection of technologies that are suitable for the optimization of the relevant sub-processes results is necessary. Therefore, it is important to refine this list with the aim of selecting a single technology to be implemented in the second phase of the dissertation. Thereby, we will use the same methodology used above (MCDA). Firstly, we will use a matrix

which allows us to benchmark the different technological solutions, since its output will indicate the degree of importance of each one in proportion with the others, however choosing the final technology from this matrix would be imprudent, due to the relevance of the various sub-processes where they will be applied, estimated previously, will not be considered. For that reason, our methodology will consist of adjusting the MCDA methodology to this specific cases and taking in consideration the relative weight of each sub-process to obtain the intended result.

As soon as we have the relative weights of each technology we select the most relevant ones and design a new model relating the technologies and sub-processes with recourse to the AHP scale. Based on the final data it is possible to select merely one solution of interest.

The matrices represented in the Tables 2.2 and 2.3 are representative of those we shall be using.

	T1	**T2**	**T3**	**T4**
C1	0,7	1	0,5	0,8
C2	0,7	0,5	0,3	0,5
C3	0,75	0,5	0,25	0,25
C4	1	0,25	0,5	0,25
Cn	0,5	0,75	0,25	0,5
Sum	3,65	2,5	1,8	2,3
Weight	0,36	0,24	0,18	0,22

Table 2.2: Technologies weights matrix, with normalized scale.

	SP1 (0,5)	**SP2** (0,17)	**SP3** (0,17)	**SP4** (0,17)	**VALUE**
T1 (0,36)	1	3	-	5	0,67
T2 (0,24)	1	1	-	5	0,37
T4 (0,22)	3	3	1	7	0,74

Table 2.3: Final evaluation matrix, with AHP scale.

As regards the first Matrix (Figure 2.2) , it consists of an assessment of the initial list of technologies according to established assessment criteria as explained previously. This matrix is filled with standardised values (0-1) as the following example suggests (Very good=1 , Good=0.75, Medium=0.5, Bad= 0.25, Very Bad= 0). Afterwards it is summed up and subsequently converted to percentage, as we can see in the equation 2.1.

$$Weight_{T1} = \frac{Sum_{T1}}{Sum_{T2} + Sum_{T3} + Sum_{T4}} \tag{2.1}$$

Concerning to the second Matrix (Figure 2.3), it only considers the most relevant technological solutions, according to the results of the 2.2 Matrix. Thus, the strategy is to relate technologies to sub-processes bearing in consideration the relative weights of both the solutions and the processes. This connection is performed using the AHP scale (2.2), allowing the quantification of the importance of each technology across the whole process. Having all these factors in perspective, the value column is obtained according to equation 2.2.

$$VALUE_{T1} = 1 \cdot weight_{SP1} \cdot weight_{T1} + 3 \cdot weight_{SP2} \cdot weight_{T1} + 5 \cdot weight_{SP4} \cdot weight_{T1} \quad (2.2)$$

2.2 Technology implementation

Firstly, it is important to point out that this project could take several paths, depending on the final outcome of the digital transformation methodology applied to the processes of the Service business unit. Thus, the implementation stage may involve two main phases. In case the tool has to be developed from scratch by the team there will be a development phase following the methodology that will be explained posteriorly. On the other hand, if the tool has been previously developed, or is an acquired tool, the implementation phase will be limited to the integration phase with the reality of the Service business unit. This last phase, like the first, will also follow a teamwork methodology to ensure that the work performed constantly aligns with the diverse views of the team members.

Regarding the first phase, the tool development, in reaction to traditional forms of software development, the need has been arisen to find alternatives for wide software development and documentation guidance [19]. In recent years, especially in IT companies, it has been evident that the use of a simple model like prototype development is not sufficient to meet the functional and non-functional requirements inherent to the project.Due to this problem, agile methodologies have begun to emerge, grounded on the adaptive nature, anticipated delivery and flexibility in life cycles. Studies also suggest that the implementation of these technologies give maturity to the organisation, improve the levels of Capability Maturity Model Integration (CMMI) [20], the productivity and reduce not only defect rates but also project overruns [19].

Currently there are several frameworks of agile methodologies, but not all are indicated to the particular situation of each project, for that reason it is necessary to identify which one matches the reality of the company and only thereafter implement it. Besides this, there are frameworks that are very complex and difficult to use. In this dissertation we will adopt the SCRUM model, since it is currently used by the department where this dissertation is being developed, parallel to this fact, SCRUM has a number of advantages in relation to the others as can be seen in Table 2.4, adapted from [20].

SCRUM	OTHERS
More prescriptive, formal meeting structures, well defined roles and iterations	**Kanban** Less prescriptive, no formal meetings, indefinite roles and iterations
Productivity is given topmost priority leading to customer satisfaction and is more flexible	**XP** Less flexible and production is not given much priority
Effective communication among team members, less complexity involved	**FDD** Less communication, more complex procedures involved
Better communication amongst team members	**DSDM** Less communication amongst team members
Procedures followed are easy and complex	**ASD** Complexity in procedural structure
User requirements strictly define development and planning, better traceability	**Crystal** Less considerate about user requirements, difficult to trace the work done

Table 2.4: Comparison of SCRUM with other methodologies

From a global vision, scrum allows the control and management of requirements and simultaneously the development of software. Being an iterative and incremental tool which subdivides a certain software and develops it in smaller parts in an iterative way. It could be applied to any project in any area, either large or small.

It must also be mentioned that this process involves a scrum master, scrum team and product owner. As mentioned above, the use of this tool (Figure 2.3) consists in the subdivision of the project in sprints that have an expected duration of 3 to 4 weeks. These sprints are determined from the sprint backlog which can be changed at each iteration according to the new requisites. They are the outcome of short meetings involving the scrum master and the rest of the team. Here the following questions are answered: "What did you in previous meet up? What obstacles are you facing? And what is in your To Do list by next meeting?" Finally, the product backlog consists of all the requirements that the final product must include [21].

Following this logic and approach, it is necessary to execute it, with the primary objective of developing the previously established technology. Initially it will be necessary to make a state of art with a higher degree of detail, as a mean to be possible to plan the work that will be required. For this planning to be feasible, it is necessary to comprehend exactly in what the project consists with the aim of developing a WBS and a SBS. These tools, reveal themselves quite important in the mapping of the work, since they allow to have a vision under the activities that are necessary to perform (WBS) and also a system architecture of the technological solution (SBS). Finally, once developed and with the purpose of scheduling the necessary work, it is possible to design a

GANTT diagram illustrating the different stages of the implementation process.

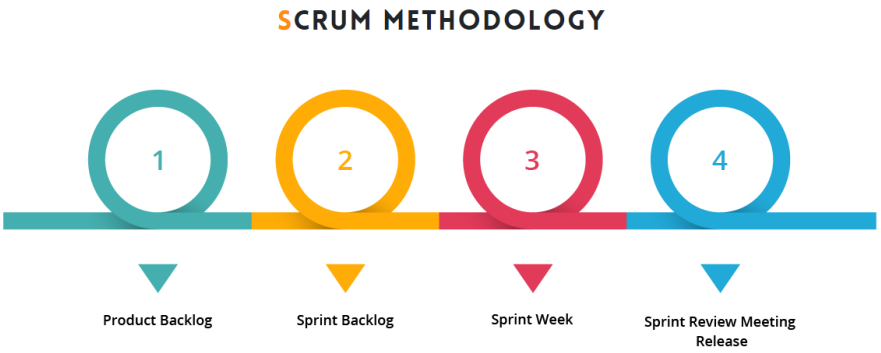

Figure 2.3: SCRUM Methodology [4]

Regarding the second phase, the implementation, once the tool is operational, whether it was developed internally or by an external entity, it is necessary to integrate it with the company's environment. For this purpose, it is extremely important that all the loaded data in the software has the validation of the process manager and the rest of the team, preventing misunderstandings and errors that can eventually lead to structural failures in the system. Therefore, similarly to the SCRUM methodology, recurring meetings must be conducted with the intention of validating all the work developed. It should be noted that in the case of an acquired technology, there will have to be an extensive study about this software, since, as there is no development phase, there was no place for a bibliographic review about the technology, only a superficial study in the analysis of every tool.

Once implementation is accomplished, the aim is to monitor and evaluate the effects caused when the process is implemented and draw relevant conclusions. As everything is aligned with the reality of EFACEC, it is essential to update the process map in coherence with the new value added to the business.

To conclude, there is a notorious need to ensure the sustainability of the project, thus guaranteeing reliability, replicability and measurably. The preservation of these pursuits is crucial for the continuity of the process in the business context.

Finally, it is important to note that, since this project could take several paths, to put it differently, at this moment we do not have any knowledge of which process will require an intervention in terms of digitalization or which tools will be used to face this problem, so the literature review of these two concepts have to be conducted at further stages, as can be seen in Subchapters 3.2, 3.5 and 4.1.

2.3 Final remarks

In order to understand what the problem that we are facing, how it is framed in current society and how we can cope with it, it is important to conduct a detailed research covering all the concepts to be explored.

The fact that we are aware of how the problem is positioned in the industrial reality is crucial to adopt the strategies which better match it, without this perception the mistakes which may arise will be considerably more common and harder to solve.

Furthermore, it allows us to confront the strategies adopted in different scenarios, providing us with the possibility of identifying the one that not only obtains the best results but also the one that best suits our case. It also provides an opportunity to combine the strengths of different approaches, resulting in highly interesting new methodologies.

However, it is important to bear in mind that the methodologies found will necessarily have to be adapted to industrial reality.

Chapter 3

Digital Methodology Approach

The project to be developed can be divided into two major areas, such as DT framework and implementation of the proposed technology. For each stage, they can be subdivided into specific activities. In this section we will focus on the initial phase, which was developed after an exhaustive study previously analysed, Chapter 2.

This methodology is based on concepts found in the aforementioned research, however it contemplates entirely new steps, developed with the EFACEC team. These stages are crucial for framing the methodology in the business context, since, for instance, the existing literature does not cover the subject "Digitization Degree" from the perspective that this methodology requires, as will be seen further on. Thus, and now looking at the work to be done, the methodology will have to be capable of showing what all the procedures are and how they are developed, from the tools used to cover every the activities to their ability to communicate with each other. With all this information we will be in a position to estimate the degree of digitization of each process as a mean to compare them between themselves and select the one that is at the baseline.

Subsequently, the chosen process is investigated and modeled. After a thorough knowledge of the process, it is necessary to pre-select the technologies that will be able to support the process. Finally, and bearing in mind several perspectives of the process, it is necessary to establish evaluation criteria and their relative weights in order to select a technology to implement. To perform this last step it will be important to conduct a new research and bibliographic background with the tool, to beginning a new phase of the project.

The entire work plan described can be visualised in Table 3.1.

Phases	Activities	Output	Tool	Observations
DT Methodology	Assessment of the unit process	Department mapping		High level analysis
	Determine the digitisation degree of processes	digitisation degree of processes	4X4 Matrix	
	Select and model in more detail the process of interest	Process identified		Ensure that the result is aligned with the rest of the team
		State of art (Process in focus)		In order to be able to analyse the process properly
		Process modelled	Bizagi	Low level analysis
	Assessing sub-process importance	Sub-process weights	MCDA	AHP scale
	Establish evaluation criteria for technologies	Evaluation grid		Criteria in line with EFACEC's reality
	Pre-select suitable technologies	State of art		Not detailed, just a general background for its assessment
		List of pre-selected solutions	MCDA	Without sub-processes in consideration
	Assessing the technologies	Ranking of technologies	MCDA	Bearing in mind the importance of each sub-process
Technology Implementation	Select and contextualize the technology on the market	State of art		
	Implementation phase	Technology development		If it is not necessary to develop it (e.g. it is not an acquired tool)
		Technology integration		
	Monitoring and evaluating effects	Results of the changes	DT methodology	Digital degree update
	Redesigning the process map	Redesigned process map	Bizagi	If necessary
	Ensuring sustainability of the process	Sustainable process or guide lines		Providing consistency and added value to the work done

Table 3.1: Work Plan

3.1 Digitization Degree

The first activities were focused on an investigation regarding the working method of the Service unit, based on the map previously drawn by EFACEC of the entire structure of the department, as shown in Figure 3.1. This process map is divided into two large groups, the left and coloured part corresponds to the type of process (transversal to the entire EFACEC) while the right side illustrates all the Service processes. Moreover, it is important to mention that the "Physical Asset Management", "Digital Asset Management", "Upcycling & Recycling" and "Integrated Solutions" elements represent the business areas of the business unit.

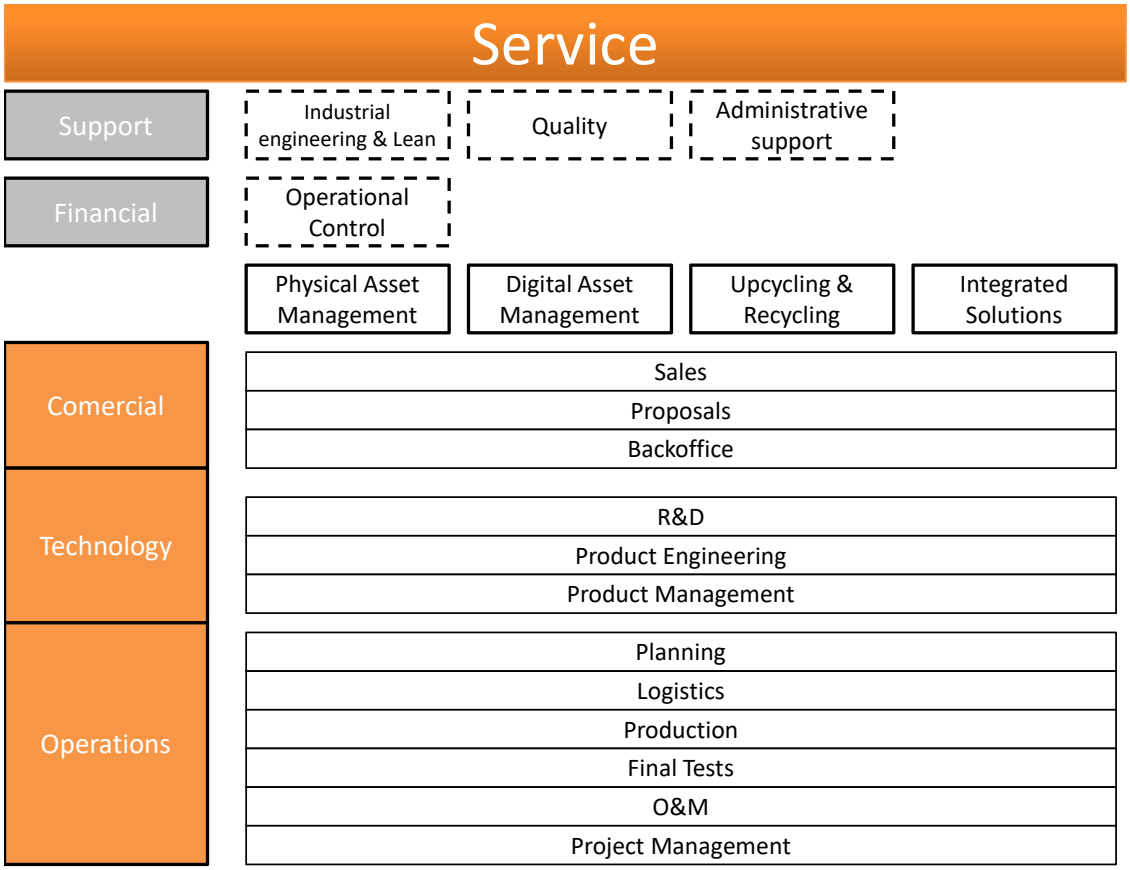

Figure 3.1: Service's Process map

Thus, to develop the work, it was necessary to have meetings with all the managers of each process to compile all relevant information for a subsequent evaluation of the technological degree of processes, including, for instance, what is performed during the process, how it is monitored, how communications are handled, or other relevant aspects of the project. It is important to emphasize that all these meetings were attended by the head of the Industrial Engineering and Lean Department, due not merely to his comprehensive knowledge of the unit's operation, but also to his involvement in the investments in instruments that might be currently being developed. This

last topic is quite frequent, mainly in large enterprises, where there are several initiatives for workflow optimization, therefore this is an aspect that must be considered in the digital transformation methodology.

In addition to the meetings mentioned above, it was necessary to build two registers in parallel, as a mean to preserve all relevant information from the mentioned sessions for a posterior analysis.

Regarding the first, presented in Tables 3.2 and 3.3, it satisfies the need to have an overview of what is carried out in every process, containing the following information:

- **Trigger:** Which action or actions cause the start of the process.
- **Result:** The key result after all the transformations associated to the process life cycle.
- **Inputs:** All document templates, rules, data (e.g. suppliers, customer history), and so forth that are fundamental for the execution of tasks.
- **Outputs:** All documents and updates that result from tasks performed by employees, for example, milestones (e.g. reports), invoices, data (e.g. feedbacks, data updates), and others.

Additionally, it was also necessary to register concrete information to achieve a meticulous evaluation of the technological level could be made according to some criteria that will be explained posteriorly. Thus, in this second register, the following records, of the daily actions of employees, were collected: the tools used to develop the work, the communication channels and interaction forms not exclusively within the team but also between departments and with external entities, such as customers, suppliers, and others. It was also considered the form of monitoring the daily work of each process team, as well as any suggestions for improvement that each head office could provide.

Once all pertinent information had been compiled, it was necessary to assess the technological level of individually every process. For this purpose, several criteria were created, as shown in Table 3.4. During the conception of the indicators, the major concern was to cover the maximum number of process areas, bearing in mind that the same indicators must contemplate various types of processes, from the most technical to the most interpersonal. With this premise in consideration, the next points will be evaluated:

- **Internal team communication:** How team elements communicate and exchange documents between themselves.
- **EFACEC internal communication:** How the several departments that are involved in the process and belong to EFACEC communicate.
- **EFACEC external communication:** The method used by the company's employees to communicate with external entities, such as suppliers, customers, and others.
- **Monitoring:** How process indicators are monitored.

- **Document management:** How all documents of interest are stored and how they are integrated in the projects.
- **Technical tools:** Tools used for specific process work for example, stock management, component design, financial control, etc.

The election of these topics resulted from an intense research of the daily business world where the topics that were considered to be most important were selected.

Regarding internal communication, it should be emphasized that it was divided into two parts, since at lower levels it is commonly divided between the team and the rest of the departments, although at higher degrees it is probably the case that the application covers both fields therefore, in this last case the classification will be equivalent. Thus, regarding its importance to the organization, it proves to be extremely crucial as it is the key to keep all employees informed about any area of the company, keeps people engaged, in times of crisis is essential to preserve the calm in the organization and also allows the creation of channels for feedback, debate and brainstorming [22].

Concerning external communication, it is extremely important, particularly with customers and suppliers. The development of strong ties between the company and these entities will undoubtedly lead to business growth, not only due to the improvement of the relationship with the client and its retention, but also to a symbiotic relationship with suppliers, building beneficial agreements for both.

As far as monitoring is concerned, this demonstrates an importance in team productivity, since, if consistent, it can translate into a competitive advantage. Productivity is increased due to the possibility of quantifying the performance of employees, defining team and individual targets. Lastly, it allows for the design of strategies oriented to the process needs, enabling decision-making based on facts [23].

Regarding document management, it reveals to be a basilar element in the growth of a company's competitiveness since it ensures the support and organization of processes, guaranteeing the quality of operational needs. Hence, we can conclude that a solid and accessible document management translates into an economic business growth [24, 25].

Finally, the technical tools used during the process were considered. Their evaluation is very important to assess the degree of digitization of the unit, since these tools are vital in the life cycle of the process and if they are disintegrated and/or underdeveloped they will lead to serious constraints in the execution of the process, which, consequently, will have nefarious effects for the company.

To each criterion it was necessary to associate a weight to approximate this methodology with the reality of the entrepreneurial world. The distribution was studied based on the contribution of every parameter to the performance of the process, in other words, the importance of each criterion from the beginning of the process to its final stage has been considered, and the following weights were established: Internal team communication: 2; EFACEC internal communication: 2; EFACEC external communication: 4; Monitoring: 2; Document management: 4; Technical tools: 4.

Concerning the levels of assessment, these are comprised between zero and five, where zero is the absence of technologies during the process and five is the maximum level of development, interoperability, and maturity of the tool used. Regarding internal communication, as mentioned above, at the highest levels it might be verified that the same tool is utilized in both criteria, however, in order to prevent situations in where different tools are used, it was decided to segregate the communication within the team and the communication between EFACEC departments. For clarity and as a mere example, the following suggestions are presented for each of the criteria in Table 3.4.

	Process Name	**Trigger** Start of the process	**Result** Purpose of the process	**Inputs** Data ormaterials	**Outputs** Data ormaterials
Support	Industrial Engineering & Lean 1º industrial Engineering 2º Lean	1º Identification of an improvement need (equipment/infrastructure) 2º Identification of an improvement need (process)	1º Modification of equipment/infrastructure 2º Process in focus optimization	Project reports	Project reports updated
	Quality	Audits: - Programed (ex. annually) - Client Request (unusually) -Customer complaints	Audit performed	History of audits Annual plan Cross-cutting audit information	**External**: Audit report (external team) Renewed certificate **Internal:** Report (Opportunities for improvement)
	Administrative support	Travelling requirements (tickets+accommodation) Request for overtime recording by employee	Travel/accommodation booking Recording of hours in the HR platform	Travel requirements form Extra hours record	Travel tickets / accommodation voucher Platform update with number of hours
Finance	Operational Control 1stReception 2ndInvoicing 3rdManagement Control	1stCostumer billing 2ndInvoice order/date update request 3rdCyclic	1stClient reception 2ndinvoice issued/ update forecast 3rdState of play, performances assessments (ERP and OLAP)	1stClients record (on the debt map and dashboards) (ex. average deadlines) 2ndInvoicing rules (electronic or paper), rules for returned invoices, 3rdControl values	1stUpdated maps 2ndInvoices 3rdControl information

Table 3.2: Support processes fact sheets

	Process Name	Trigger Start of the process	Result Purpose of the process	Inputs Data ormaterials	Outputs Data ormaterials
Commercial	Sales	Business opportunity (active or passive)	Request to open the SO (sent to planning)	Qualification matrix Rules for registering opportunities in CRM, Guidelines for proposal scores	Customer proposal (for BAAN registration)
	Proposals	Need to detail a proposal to a client/tenderer	Proposal to the opportunity (sent to commercials) Validation of accepted proposals (the opportunity has already been awarded)	Proposal template OS opening validation (excel) History of past orders	Proposals (sent to commercials)
	BackOffice	Proposal (internal/external), opportunity	Request to open a SO Closure of the opportunity in CRM and request to open the SO	Procedures (e.g. closing proposals, analyzing budgets, etc.)	Service order opening request (Email)
Technology	R&D 1st Digital transformation 2nd Business areas	1st Need to optimize the workflow of a process 2nd Need for a new product/solution/service	1st Tool created 2nd New product/prototype(specifications)	Datasheets Webinars Articles Standards	Specifications report (sent to client)
	Product Engineering 1st Tendering 2nd SO	1st request for proposal (tendering) 2nd SO is communicated	1st proposal made 2nd analysis done (sent to the planning/project manager)	History of interventions, report templates (e.g. equipment)	Completed reports (all information of interest sent to the project manager)
	Product Management	Need for Innovation; Market stimulation	New product/solution/service ready to market	Resources availability Product requirements	Product specifications Product price Product marketing Product roadmap
Operations	Planning (supply chain)	Receipt of the SO opening request (sent by Backoffice)	SO opening, requisition of materials and services, definition of supply deadlines	Request to open a work order (Email: budget, proposal, and order); Communication template for opening the SO	BAAN/SPOT Update SO opening email
	Logistics	Warehouse requisition (from planning); Transport request (by planning/project management)	Delivery of material completed; Transport order sent	Warehouse Application Form (BAAN)	BAAN update of material delivery BAAN update with receipt of shuttle service
	Production	Receipt of SO opening information	Concluding the practical part of the SO	Tender documentation; Work planning (tests + repairs)	Updating the load map
	Final Tests	Need to do tests (entry / end)	Test performed	Report Templates	Completed reports
	O&M	-Spontaneous process at the Pego power station (repairs of mechanical or electrical equipment) -Periodic evaluations	-Equipment repaired -Assessments performed	Logistical documents (e.g. materials, tools, human resources)	-Monthly invoices -Final reports for each intervention (online)
Products Operation	Project Management	New SO opening information	Request for closure of the OS (to operational control) Invoicing request (to operational control)	SO opening email Report template (e.g. equipment)	Technical report of the SO Cash-flow analysis Cost analysis

Table 3.3: Core processes fact sheets

Internal communication						
Team communication (50%) How team members communicate and exchange documents	**Internal EFACEC communication (50%)** How the different Efacec departments communicate with each other	**External EFACEC communication** Communication with suppliers, customers, etc.	**Monitoring (50%)** How the work developed by the team is monitored (e.g. KPI's)	**Documental management** Tools are used daily for the management of information and documentation related to the processes	**Technical tools** Which tools are used on a daily basis by the team during the technical work (e.g. stock management, transformer maintenance, etc.), considering the context of their possible potential in the company	
0- None	0- None	0- None	0- None	0- None	0- None	
1-email/phone	1-email/phone	1-email/phone/meetings app	1- Poorly organised tool, difficult to access and with simple indicators	1-OneDrive wihout organization	1-Disintegrated Ms office tool	
2-Zoom or google meets	2-Excel updated by a single entity	2-email/phone/meetings app centralized	2-Planner or an excel manually extracted from CRM	2-Onedrive with some organization	2-Disintegrated Ms office tool with some complexity	2-AutoCad used in a basic manner and disintegrated with the rest of the business
3-Teams (used quite simply and without document management integration)	3-Teams (used quite simply and without document management integration)	3-Platform that contemplates a simple register of information	3-Excel developed for this purpose or power bi without a great degree of complexity	3-OndeDrive fully organized	3-Integrated Ms office tool with high complexity	3-AutoCAD used in a basic manner and some integrated with the rest of the business OR AutoCAD used with some complexity and not integrated with the rest of the business
4-Teams with large exploitation of its functionalities (integrated with polanner for example)	4-Teams with large exploitation of its functionalities	4-Integrated platform that allows you to track orders or deadlines and register feedbacks	4-Power BI developed with consitency	4- User friendly tool, that supports the process	4-AutoCAD used with some complexity and quite integrated with the rest of the business	
5- Communication tool with full **maturity** and **interoperability** between several systems of interest	5- Communication tool with full **maturity** and **interoperability** between several systems of interest	5- Communication tool with full **maturity** and **interoperability** between several systems of interest	5-Tool at its maximum performance and covering the whole process	5-Specific tools with full **interoperability (portability, longevity),** in the cloud and strongly protected	5-Specific tools with full interoperability (portability, longevity), and at their highest performance	

Table 3.4: Digital degrees of the Unit's processes Service

At this point, it was necessary to modify the methodology, since until this moment the coverage that each tool provides to the process was not considered. The main aspect that was considered was the percentage of use throughout the process, measured based on the testimonies of those involved. This methodology guarantees, for instance, that if a sophisticated technical tool is only used in one part of the process, the final result is not distorted, since in the rest of the process it can be verified the absence of appropriate tools to execute it, having, therefore, a low level of digitization instead of a high degree. Hence, a degree of coverage was attributed to each tool, framed with the role taken in each process and, finally, each of the percentages was multiplied by the score of that tool, solving the problem described previously. It is worth noting that if a part of the process is not supported by any tool the score attributed to that slice will logically be zero.

Now, with all the assessment method logic in mind, it is necessary to concentrate on a concrete example (Sales process) to provide a better understanding of the evaluation procedure, this example can be observed in Image 3.2.

Assessment	**55%**	
Team Communication	2.9	Email 2 (40%) Teams 3,5 (60%)
Internal communication to EFACEC	3.1	Email 2 (33%) Teams 3,5 (33%) CRM 4 (33%)
External communication to EFACEC	2	Email 2 (35%) Phone 2 (35%) Online meetings platforms 2 (25%) Linkedin 2,5 (5%)
Monitoring	2.5	Excel exported from CRM 2,5 (100%)
Document management	3	share comercial 3 (80%) share tendering 3 (20%)
Technical tools	3.1	CRM 3 (90%) PMO Forms 4 (10%)

Figure 3.2: Example of evaluating a process (Sales process)

As it is possible to verify in each field the tools used throughout the process were identified. It is important to note that it is necessary to understand how each tool is used by employees and not rate it based on its potential, in order to be able to assign a rating close to reality. As mentioned before it is also extremely relevant to assess the degree of coverage that each tool gives to the process, focusing essentially on their importance, this indicator is the percentage in front of each of the tool rankings. Regarding the color code, it follows a similar logic as the Figure 3.3. It must

also be noted that it is necessary to ensure that the sum total of all the degrees of coverage of each area is 100%, so if there is a part of the process that has no tool as support, this must be ranked with zero. To calculate the degree of process digitization the following formula was applied:

$$DigitalDegree = \frac{\frac{2,9\cdot 2+3,1\cdot 2+2\cdot 4+2,5\cdot 2+3\cdot 4+3,1\cdot 4}{2+2+4+2+4+4}}{5} = 55\% \tag{3.1}$$

Finally, it is important to mention that the same tool could be rated differently in certain occasions, namely in the case of being exploited in different ways at different moments, in other words, in a specific stage a tool could be used almost at its maximum potential, but in another phase it could be used in a simplistic way and away from its full capacity. In another case, a real example is the assessment of "Teams" in terms of internal and external communication, since, regarding the first, its potential is very strong, however, concerning the second, in the majority of the cases, the platform only execute meetings and does not allow the management of the communication process with the external entity. The results of the methodology described are presented in Table 3.5.

Comercial	**Digital Degree**
Sales	55%
Proposals	58%
Backoffice	41%
Technology	**Digital Degree**
R&D	60%
Product Engineering	56%
Product Management	33%
Operations	**Digital Degree**
Planning	45%
Logistics	54%
Production	46%
Final Tests	49%
O&M	76%
Project Management	38%
Support	**Digital Degree**
Industrial Engineering & Lean	42%
Quality	58%
administrative support	50%
Financial	**Digital Degree**
Operational Control	45%

Table 3.5: Digital degrees of the Service business unit processes

To obtain a closer view of the unit's reality, as mentioned in Chapter 2, the results obtained were expressed in a matrix of three dimensions(Figures 3.3and 3.4). on the horizontal axis is reflected the integration of the tools used during the process in the business context, so the higher the interoperability between the process tools the further from the origin it will be positioned. The vertical axis refers to the technology potential, regardless of whether it is integrated with other tools or not, which means, on the one hand, the closer to the origin the weaker the potential of the available technology, on the other hand, the further away the more sophisticated the technology used. Finally, the third dimension is present colour coding. The orange colour represents technological initiatives occurring exclusively in the process in interest. The blue colour is similar to the previous one, although the initiative is transversal to other EFACEC processes and not limited to the process in focus. At last, the green colour represents the absence of improvement projects. Note that this last dimension is very important for the decision-making phase concerning the process that will be digitized, since after the initiative is concluded, the process digitization level will certainly be higher.

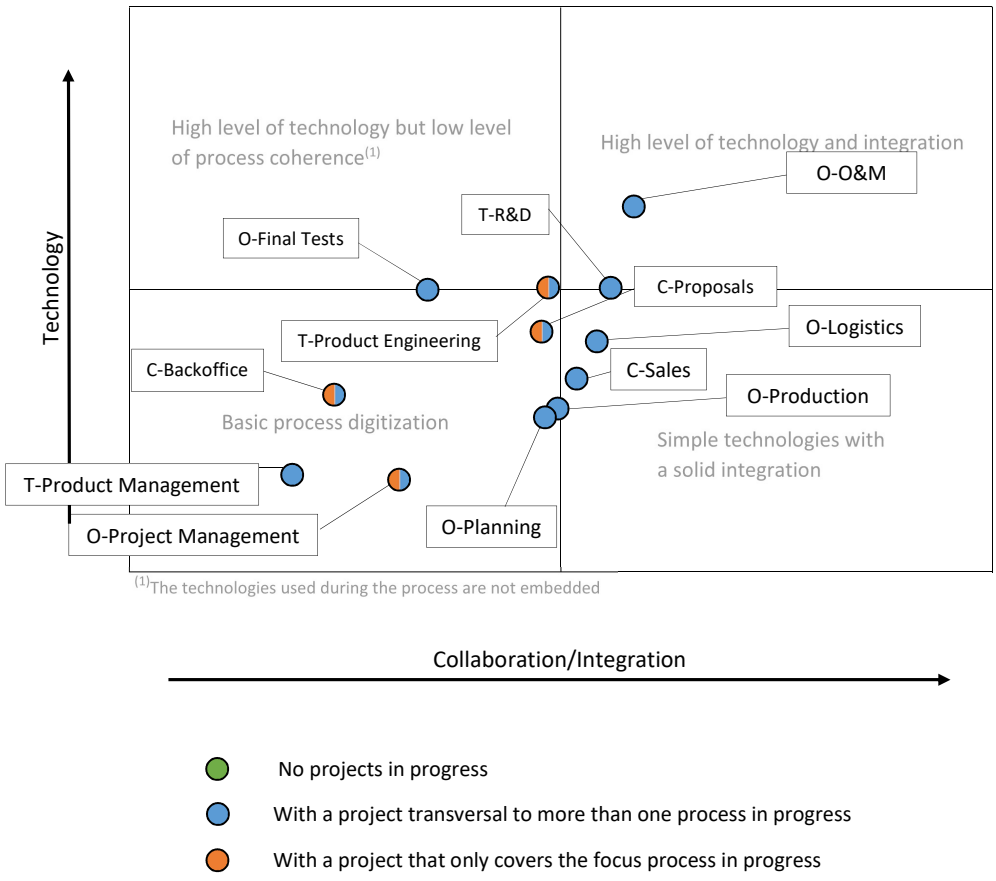

Figure 3.3: Matrix of Digital degrees of the Service business unit core processes

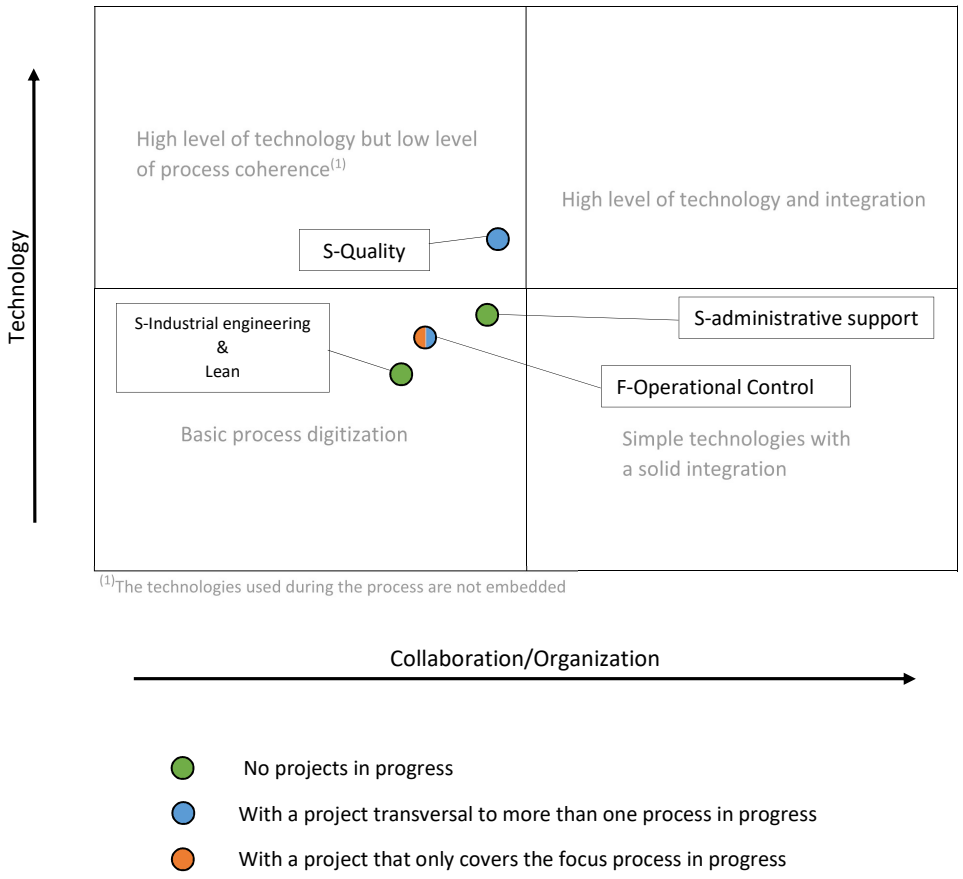

Figure 3.4: Matrix of Digital degrees of the Service business unit support processes

After a careful analysis of both matrices in conjunction with all the company's stakeholders, the process chosen for intervention was the one with the lowest degree of digitization, "Product Management". This decision was made bearing in mind the fact that an initiative is currently underway, however, this will only contemplate the part of document management, which means that it will not modify the degree in an accentuated form capable of overtaking processes that are in the surrounding area.

Finally, it should be noted that the processes "Back-office" and "Project management" are the processes that are nearest to the one selected, however, as they have several initiatives underway they were excluded, since, at the end of them, the position of these processes will be clearly closer to the most digitized processes.

3.2 Process State of Art

The technological analysis of the unit's processes detected that the most overdue project in this area and the one that needs an intervention is product management.

Actually, this is a process that has neither a solid structuring nor initiatives that promote its restructuring.

Thus, a new meeting was conducted with the process manager, with the purpose to inform and obtain approval to this intervention, starting a new phase of the methodology, the state of the art of the product management process.

This preliminary step is fundamental, since it allows a first interaction with the process, especially in case where there is no previous knowledge about it, it is crucial to understand how it fits into the business and which is the best approach to consider. In this specific case, this step proved to be fundamental, since it was necessary to redesign the whole process, as it will be possible to verify posteriorly.

After an exhaustive research, we focused on the concept of product lifecycle management (PLM), noting that in this case the product is a service provided by the unit, such as transformer maintenance.

Regardless of whether the product is a service, its management is crucial for the competitiveness of the company. Nowadays, it is not possible for a product to remain stagnant throughout its life, it is necessary to make a personalized follow-up of each one, with the purpose of increasing competitiveness by offering higher value to the customer, adapting processes, for example. The focus on managing the entire life cycle of a product from its conception to its reuse or withdrawal from the market is clearly evident, with the aim of companies remaining competitive [26]. In other words, the life cycle of a product is very similar and in most cases respects the following order of ideas, conception and development, introduction into the market, growth, maturity, and decline. Varying according to the product, the strategy and the duration of its cycle. Thus, the more controlled this process is, the higher the level of competitiveness of the company. [27]

To meet customers' needs it is not sufficient to be concerned only with the price of the product or its quality, it is imperative to focus on areas such as reliability or time to market, for example.

As the level of development of the product management process is quite basic, it was necessary to deepen the research regarding the process in order to implement the best strategy to control the life cycle of the unit's products, in other words there will have to be a restructuring in the way the process works and an analysis down to a relatively low level as it will be possible to see below. Firstly, it is essential to look at the whole process from a high level, with the purpose of covering its whole life cycle. Therefore, it was necessary to organise it in three phases, beginning of life (BOL), middle of life (MOL) and end of life (EOL) [28]. As shown in Figure 3.5. It should also be noted that the input of this process comes from the EFACEC structure, in other words, both the objective and the scope are inputs derived from a transversal strategy for the company.

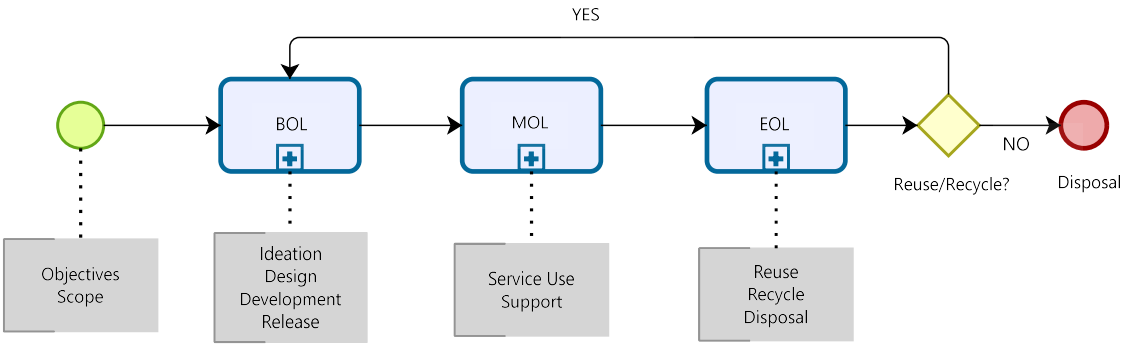

Figure 3.5: PLM process

Note that these three sub-processes will be the ones used in the Table 2.1.

Concerning the BOL sub-process, the T-plan standard from the University of Cambridge was adopted [29].

This methodology consists of a series of four workshops with the aim of simplifying the product launch while maintaining its quality.

In an initial phase, it is necessary to develop a technology roadmap planning (TRM) that will have as main input the existing product portfolio, as well as some strategic knowledge of the company. TRM can be executed in several ways, however, in this case, the roadmap previously implemented in EFACEC was adopted, comprising a multi-layered time-based diagram on which the evolution of market, product and technology is plotted, showing key linkages between the tiers. Subsequently, this plan will be approved by the unit director and we will move on to the workshops. In the first, there is a short contextualization of the team with the planning and with the T-plan concept, the company's objectives are confirmed and an analysis of the market and of the business drivers is conducted, which are identified and prioritized by segments. The strategic position is also established, regarding opportunities, threats, strengths and weaknesses (SWOT analysis). Finally, the team's knowledge gaps and future work are identified. It has as input the Strategic Plan (PE) and the Strategic Plan for Technological Development (PEDT). The output will be a final workshop report that will be included in the final TRM.

Next, the second workshop starts, is focused on the product roadmap. It should be noted that this product can be a physical product or a service provision. In both cases all tangible aspects that are part of its development are considered as well. In this phase, all the product features are considered, based on the market insights and the business drivers from the previous workshop, that we can consider the main inputs. For its part, the output will be the concluding report, containing crucial information such as the strategy, concept and impact of the features and knowledge gaps.

Regarding the third workshop, this one focuses essentially on the technological component of the market, however some business aspects that need to be developed by the team, such as competences or skills, may also be considered. The main goal of this workshop is to find technological solutions capable of delivering the product features previously established in the second

workshop. In other words, the workshop's final report should contain a ranking of the potential solutions discussed based on the impact on the product's features. Similarly to the last meetings, gaps in the team's knowledge and future work are also identified.

Concerning the fourth and last workshop, it starts by analysing the final reports of the last three meetings. Then, the global planning of the product is developed in a more detailed form, such as the technological roadmap, the market mapping, strategic milestones, its evolution and the type of technologies to be implemented. This last meeting is responsible for gathering all the pertinent information about the new product and structuring it in a suitable way to ensure its successful launch [29].

Finally, and already with the whole plan duly organised and scheduled, resulting from the work developed during the four meetings, all information is sent to the respective departments so that the launch of the new product can be initiated. So the BOL sub-process is considered completed, all the process is presented in Figure 3.6.

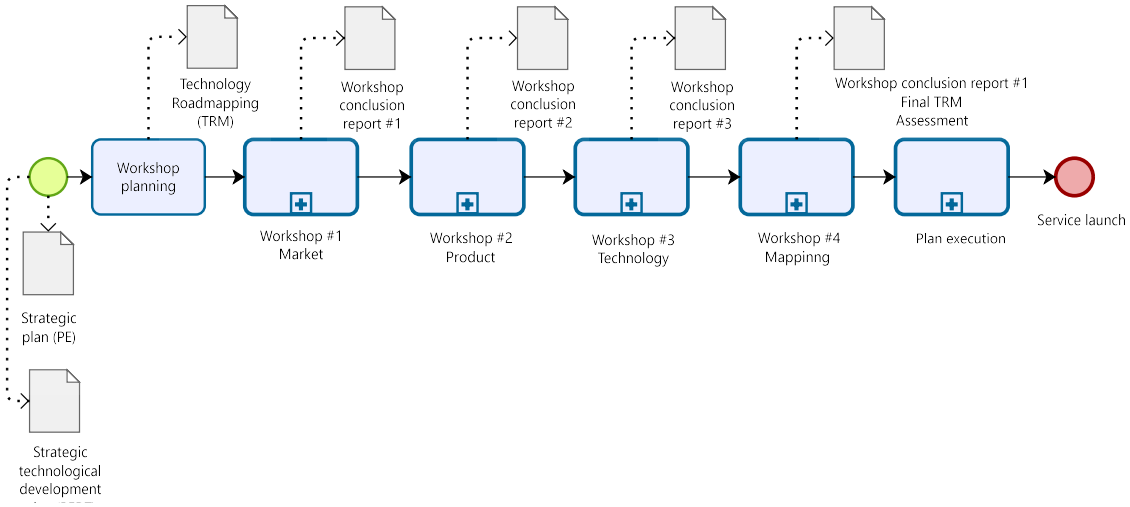

Figure 3.6: BOL subprocess

Regarding the MOL sub-process, presented in Image 3.7, it starts from the moment that the product is launched, after this event, the product/service provided is monitored by a surveillance network. This action is fundamental to the MOL, since it is in this activity that more time is spent. It is essential that all services provided to customers by the unit are properly monitored so that if problems or optimization needs are detected, initiatives can be implemented as quickly as possible. These actions should be adopted based on a detailed analysis of the data collected and with the participation of actors from various departments so that the action plan can be the most effective possible. Note that if the conclusion about the product falls on the obsolescence of the same is the end of the MOL, initiating the EOL, however, if the same is not detected the team starts the execution of the action plan, this can be from a change in the service procedure to the maintenance of some tangible asset, for example [30].

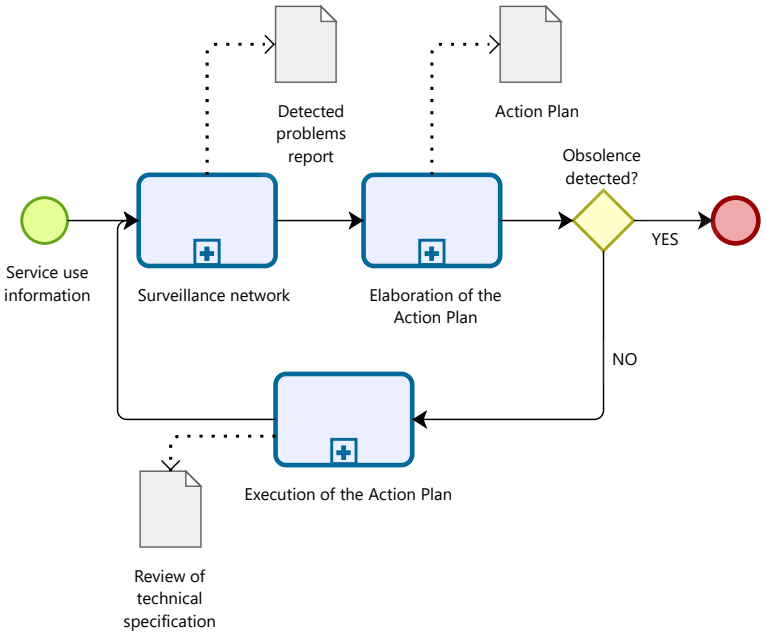

Figure 3.7: MOL subprocess

Finally, only the EOL sub-process remains to be analysed. Thus, as explained above, it starts when the obsolescence of the product in question is detected. As soon as the process begins, it is imperative to analyse all the data received from MOL, in order to allow a rigorous analysis and obtain viable solutions for the company, with the aim of recycling, reusing or even withdrawing the product from the market. This sub-process is also considered as reverse logistics, collecting information about the parts and the material that will still have value for the business [27]. According to the solutions found by a diversified team, the process flow might follow different paths, in case of being possible to its reuse/recycling, it will be necessary a structural reformulation in several aspects, such as the market or the technologies used, so the process flow should be directed to BOL, to be redesigned and worked in consonance with the company's objectives. This sub-process is illustrated in Image 3.8.

With a solid and well-organised product management process structure, as the one discussed previously, it is possible to derive several benefits divided into four large categories such as improved financial performance, reduced time to market, improved product quality and, perhaps most importantly, improved business performance [31].

Finally, taking into consideration all the sub-processes and their role in the business environment we are already able to adapt the 2.1 Table to this reality.

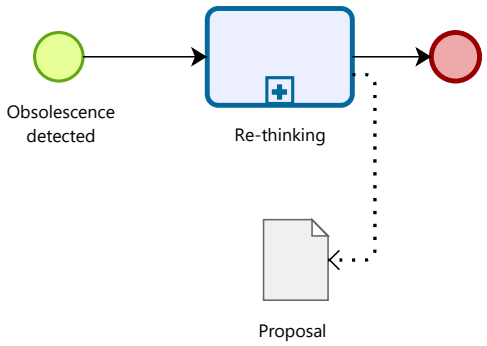

Figure 3.8: EOL subprocess

3.3 Weight of sub-processes

As previously mentioned, according to the proposed methodology work plan (3.1), in this phase it is necessary to evaluate the weight that each sub-process represents for the process. In this context, an evaluation table was developed with the objective of measuring these weights according to the AHP scale (2.2). Thus, and in agreement with the head of the product management team, the sub-processes were evaluated, with this step depicted in Table 3.6.

	BOL	MOL	EOL	Weight
BOL	1	9	9	0.82
MOL	1/9	1	1	0.09
EOL	1/9	1	1	0.09

Table 3.6: Sub-processes's weights

With the results obtained in mind, it is possible to conclude that the BOL sub-process is extremely more important than MOL and EOL, from the perspective of the company's product management team. This assessment is based on the premise that the planning process together with the various analyses of the product strategy are crucial for the entire product life cycle, in the case that these components are not solid and effective, the downstream processes will be strongly affected.

Note also that the weight of Table 3.6 was obtained according to the following equations:

$$Weight_{BOL} = \frac{1+9+9}{1+9+9+(1/9)+1+1+(1/9)+1+1} = 0,82 \tag{3.2}$$

$$Weight_{MOL} = Weight_{EOL} = \frac{(1/9)+1+1}{1+9+9+(1/9)+1+1+(1/9)+1+1} = 0,09 \tag{3.3}$$

3.4 Technology assessment criteria

It was decided to strategically place the criteria analysis at this point, since it will facilitate the tool research in the next phase. This is due to the fact that from this moment we will have a better picture of what the tool will have to cover. With the purpose of establish the criteria that the tools will have to meet, new meetings were organised with the rest of the team. These conferences proved to be essential since the alignment with the strategy and the vision of the company is fundamental not just for the coherence of the methodology but also for the health of the company.

Regarding the criteria, the following were selected:

- **Mapping (e.g. gantt):** Possibility to map the work to be done for each product, not only the project phases but also the features and the requirements to be implemented.
- **Progress monitoring:** Ability to monitor the release progress, such as what has already been implemented, what remains to be implemented or even what will no longer be implemented.
- **Product datasheet:** Information on each product to identify its requirements, specifications and design method.
- **Business case for each product:** Strategic points for each product to assess its viability and the profitability of the investment.
- **Technology analysis:** Allow the recording of a technological analysis of each product, from its positioning relative to the present to the objectives and initiatives that each project may have.
- **Market analysis:** Analysis of various market factors such as size, competitors, customers, among others.
- **Product life cycle:** Information regarding the product life cycle from roadmaps to goals such as invoicing, spending, and others.
- **Project data management (PDM): client source:** Data on the quality of our products, the main source of information are the customers.
- **Product Focus Data:** Data that allows monitoring of the product after its launch, conception times, number of services provided, machine failures, and others.
- **Details of the product development process:** Information of the team *modus operandi*, how it is done, what machines are needed, who does it, and so on.
- **Installation costs:** Acquisition or subscription cost of the tool, in other words the cost can be a one-off purchase, or a monthly/annual payment.
- **Operational costs (monthly):** Cost of tool maintenance including the effort of continuously updating the information.

- **Development costs:** Development costs of the tool, in cases where it is necessary to build the system, as is the case with Office tools.

- **Implementation time (tool development):** Development time that the tool requires, from the beginning of its conception (in cases where it is necessary) to the final implementation phase in the department.

- **HR impact:** Human resources effort for the implementation and use of the tool.

- **Fitting in with the company's universe:** Compatibility of the tool with the company's reality. In large companies this requirement is very important since the various business units should operate in similar models.

Now, with all the criteria in mind we move to the next step, discovering technologies capable of supporting the product management process and making the assessment according to the selected requirements.

3.5 Pre-select suitable technologies

Researches were conducted on various websites and rankings and the tools were selected which, after a brief initial contextualisation, showed the most potential to fit the criteria previously defined. In addition to this, meetings were also organised with other EFACEC departments, in order to verify which tools are currently used in this type of process, which proved to be fundamental to guarantee the viability of the methodology, since it is crucial to verify consistency between departments.

It should also be noted that, after a meeting with Information Systems Department (DSI), all open source tools were excluded from the beginning, since, they involved information that was quite sensitive to the group and consequently the minimum security requirements were not satisfied.

3.5.1 Aha!

This tool is already used in the EFACEC universe, so it was immediately considered.

When analysed carefully it can be seen that it has a strong coverage of the initial phase of the process. Its major strengths are the support to the product strategy, requirements management, including prioritisation, release management, ideas management, visual roadmaps with all products and personalized dashboards. It is also worth mentioning the ability to combine goals and initiatives with releases and features, allowing a better supervision of the business goals. In parallel, it is also possible to set deadlines, assign people to certain tasks and track the progress of each product through the possibility of marking tasks as completed [32].

3.5.2 Project insight

The project insight was considered due to its good quotation in some analyzed rankings, such as "Capterra". With this software it is possible to schedule tasks and projects, as well as assign them to other team members. It is also possible to detect and monitor problems during the project phase, manage resources, plan the budget and make reports with relevant data on the project status [33].

3.5.3 Trello

This tool has as main functionalities the organisation of projects, the ability to manage lists of tasks and consequently assigning the responsible for each one, it is also possible to create descriptions, deadlines and objectives for each one. Every list is allocated to a board that can be shared and monitored with other users.

Thus, it is possible to conclude that Trello is a simple solution that only supports the management of tasks, without, however, having a sufficiently developed architecture that covers enough points necessary for the support of product launches [34].

3.5.4 SAP software

SAP is a very complex tool that has several modules related to product life management. Given this fact, two modules were considered that seem to be sufficient to meet the needs of the process, the "SAP portfolio and project management" and "SAP Teamcenter by Siemens".

Regarding the first module, it is based on the management of projects, tasks and timelines, being possible to prioritise and monitor all the progress [35].

Concerning the second, besides allowing integration with the aforementioned module, it also allows a quick response to market needs, with an adjustment to the client's needs. It is also possible to improve product quality and eliminate downstream errors. It offers the possibility of collaboration with suppliers and, finally, the simulation of engineering models during the provision of services and the analysis of product use supported by operational data [36].

3.5.5 Windchill

This software is also used in other EFACEC business units, in addition to being capable of integrating various ERP technologies, MES, CAD, IoT and more.

Furthermore, it has multiple features such as BOM management, change and configuration management, manufacturing process management, product data management, product variability management, quality management, requirements and testing management, and finally, service process management.

Therefore, Windchill is a very comprehensive tool focused not only on the development of products (e.g. design), but also on its follow-up throughout the life of the product [37].

3.5.6 Oracle PLM

This tool seems to be a wide solution with several concepts like innovation management, product development, quality management, product information management and configurator modelling.

Regarding innovation management, it is able to register ideas for new products, services, markets, or customer experiences and evaluate and manage them.

Product development involves rapid product development and launch, reducing costs and supplier problems, accelerating product changes and enforcing product compliance.

Quality management ensures the rapid detection of problems and their subsequent resolution, both at the product level and at the level of communication between other entities. All the information available allows quick and effective decision-making due to a larger knowledge base about the problem.

Regarding the management of product information, it provides us with all the information related to the product clean and organized.

Finally, configurator modelling gives several integrations with design and test software, permitting to assure the user experience quality through impact analysis and validation points [38].

3.5.7 Microsoft Tools

The microsoft tools cover all the necessary solutions for the stages of the product lifecycle from the planning of the products to the required follow-up during their use. Thus, more than one tool might be required, namely Microsoft Project, Planner, Excel, Power BI and others, if necessary.

All these instruments need to be built around the company's requirements, in other words, they are not specialised product management tools, but if developed and integrated for this purpose it is possible to meet the requirements described in Subchapter 3.4.

Since Microsoft is quite integrated in the EFACEC environment, it was added to the options between the other specific tools with the aim to understand whether, according to the methodology, its implementation in this specific case will be beneficial for the business.

3.6 Technologies assessment process

At this point, with a thorough knowledge of every technology it is possible to perform an evaluation according to the criteria described in Subsection 3.4.

Therefore, it was necessary to assign weights to each criterion, to evaluate every technology according to a normalised scale, in order to prevent pondering errors.

As it is a considerable number of criteria and tools, it is fundamental to know them deeply and have in mind the concept of each one of the criteria.

It should be noted that this whole evaluation process was attended by both the dissertation's external supervisor and the head of the product management team of the Service business unit.

3.6.1 Weights of criteria

The criteria weights are extremely important once it permits us to highlight those that have greater relevance from those that will not be so crucial in the process support, in other words, the greater its weight the greater its importance for the final ponderation of the tool assessment.

All criteria were explained in Subchapter 3.4, and the respective weights resulted from the average between the several opinions of the team. Finally, it was established that the weight range is [1,10].

3.6.2 Assessment according to the criteria

Table 3.7 shows all the tools considered for evaluation and the respective quotations for each criterion according to our needs in the different requirements, which means that the scores could differ according to the company where the methodology is applied and according to the business area complexity where it fits.

	Aha!	Project Insight	Trello	SAP	windchill	Oracle (PLM)	Microsoft tools	Criteria weight
Mapping (e.g.gantt)	1	1	0,5	1	0,5	0,5	1	10,00
Progress monitoring	0,8	1	1	1	0,5	1	1	5,17
Product datasheet	0,5	0	0	1	1	0,5	1	6,50
Business case for each product:	1	0,5	0,3	1	1	1	1	8,67
Technology analysis	0,5	0	0	0	0	0,3	1	7,33
Market analysis	0,8	0	0	0,5	0	0,3	1	7,50
Product life cycle	0,5	0	0	0,5	0,5	0,5	1	6,50
Project data management (PDM): client source	0	0	0	1	0,5	0,5	1	5,50
Product Focus Data	0	0	0	1	0,6	1	1	7,00
Details of the product development process	0	0	0	1	0,6	0,5	1	5,50
Installation costs	0,85	0,94	0,93	0,5	0,76	0,16	0,9	7,50
Operational costs (monthly)	0,9	0,5	0,5	0	0	0	0	7,50
Development costs	1	0,5	0,5	0	0	0	0	8,50
Implementation time (tool development)	1	1	1	0,5	0,5	0,5	0	10,00
HR impact	1	1	1	0,5	0,5	0,5	0	10,00
Fitting in with the company's universe	1	0	0	0,5	0,5	0	1	10,00
∑(Cx.Wx)	90,59	54,55	47,74	74,08	56,95	53,48	86,42	
Tech's Weight	20%	12%	10%	16%	12%	12%	19%	

Table 3.7: Techonlogies's weights

It should be noted that a normalized scale was used in all criteria, where 1 represents the best case and 0 the worst. To better represent this scale we present the following example for installation costs: 0 corresponds to a cost of 50,000€ and 1 corresponds to 0€.

3.6.3 Final assessment of the technologies

At this moment, we have an assessment of the technologies regarding the main requirements defined by the team, however, it is also required to consider the weight that each sub-process has in this ponderation, since it is very important to understand if the elected tool covers an important part of the sub-process.

Thus, to proceed this evaluation, the weights of the subprocesses, calculated in Subchapter 3.3 and the weights of each tool calculated in the previous chapter, are considered.

Besides this, the AHP scale was used, to measure the importance of the tools with respect to the subprocesses. It is possible to observe the evaluation in Table 3.8.

		BOL	MOL	EOL	
	SP's weight / Tech's weight	82%	9%	9%	Value
Aha!	20%	9	4	1	1.529362
SAP	16%	7	7	2	1.034419
Windchill	13%	2	7	2	0.319633
Microsoft	18%	7	7	7	1.289526

Table 3.8: Final technologies assessment

As an example, and taking into consideration all previously explanations, the proper method to interpret the table above is "The Aha! tool is *extremely important* in the BOL sub-process, *moderately important* in the MOL sub-process and *not particularly important* in the EOL sub-process". The same reading logic is applied to each of the other tools.

3.6.4 Results discussion

At this point, we can consider the digital transformation methodology concluded. Its final result is a technology capable of supporting a particular process that is in a worse condition of digitalization compared to the environment of the Service business unit.

According to Table 3.7, we conclude that the tool which has the highest value regarding the stipulated criteria is Aha!. This is focused essentially on the product life cycle planning phase, considered the most important of the entire process. The technology is quite encompassing in its features, since its range of functionalities goes from the management of new ideas, to the framing of the Service business unit strategy with the various business areas and their respective products.

Furthermore, it is also possible to track the development of products and schedule all stages, including releases, release phases and features, their progress, as well as the actors of the tasks.

Moreover, it is intuitive to gather and process a variety of data and generate reports and presentations. Despite all these aspects, this tool does not present much complexity in its use, leading to a relatively low effort, both in terms of time and human resources.

Finally, it is currently present in other departments of the company's structure, being, consequently, an option that is highly compatible with the company's environment, having also an accessible acquisition cost.

On the other hand, concerning the Table 3.8, only the tools that obtained the highest score in Table 3.7 and the respective weights were considered.

Bearing in mind the relative weight of each sub-process achieved in Table 3.6, we analysed the preponderance that each technology has in supporting every sub-processes, which will prevent mistakes in the final results, since a technology can fulfil several criteria without necessarily covering the crucial phases of the entire process. For this reason, it is extremely important to consider all these aspects to ensure that the results are as realistic as possible, and consequently more impactful.

Regarding the Aha! software, it was observed that this has a great impact on the BOL sub-process, a moderate impact on the MOL sub-process and has no particularly important impact on the EOL.

The SAP and windchill, on the other side, are capable of giving a "very strong" support in the BOL and MOL phase and a coverage without special relevance to EOL.

Lastly, as the Microsoft tools are considered generic tools and are directly dependent on the development made by the team, it was considered that their impact is transversal to the whole process, not being possible, however to classify them with the highest value of the hierarchy scale, with the aim to be consistent with the criteria of the methodology implemented, as described in Subchapter 3.1.

In conclusion, as the BOL was considered the sub-process with the highest impact, a tool that is extremely important in this case will be highly valued, as can be observed in the Aha! value. Therefore, and despite Microsoft tool presenting a higher coverage in general, the technology elected was Aha!, not only for providing a high coverage to BOL but also for having a high valuation regarding the criteria.

Chapter 4

Technology implementation

At this point, and after all the work developed following the methodology DT described in the previous section, we proceed to the implementation phase of the selected technology "Aha!". To this end, it is necessary to make a thorough investigation of all the software details, as a mean to use all the capabilities to their fullest potential, then, and with all the knowledge acquired, work sessions are initiated with the aim of integrating the tool in the process of product management of the Service unit.

Thus, since it is a tool already built and that will be acquired, it is not necessary the development phase, only its analysis and subsequent integration in this new reality.

4.1 Aha! software

Aha! is a product roadmap software developed for product managers. This software is able to cover a wide spectrum of product planning enabling both the manager and the team to have a extensive range of options for product portfolio planning, such as setting product/business strategy, roadmaps, idea capturing, scheduling, progress monitoring, presentations, and others. Hence, it is a slightly complex tool that will need to be analysed in considerable detail to understand its architecture and full benefits.

4.1.1 Main resources

As mentioned before, Aha! is a very comprehensive product life cycle management tool with a wide range of offers.

With the use of this software it is possible to cover product management through various solutions, including establishing the strategic plan of the unit, from the connection between the different strategies associated with each product with their releases and features, and also associate all this with the global goals and initiatives of the business unit. It is also possible to register the profile of the target customers as well as competitors, with a variety of relevant information.

Besides this, it is also possible to design various types of roadmaps, such as product development roadmaps containing the different releases, release phases, milestones and features; strategic roadmaps allowing the contextualization of the objectives and initiatives in a timeline.

Additionally, it is also possible to extract different sorts of data from the program, with the aim to create reports and dashboards synthesizing all the information contained within the program in user-friendly visualization forms.

Finally, the fact that it is possible to create templates and customize data (e.g. scorecards) in several areas is quite important to standardize the information contained in the different products and consequently prevent unnecessary mistakes.

It is possible to visualize, in a practical situation, all this aspects, in Subsection 4.2.

4.1.2 Data model

Firstly, it is necessary to comprehend the workspaces' organisational structure, since a well-organised structure at this point will facilitate all subsequent steps, such as, the establishment of objectives and initiatives, as these might be interconnected between the various levels.

When creating workspaces, it is possible to create as many levels as is convenient. In this instance, a top level referring to the company will be created, followed by a level referring to the business units. Below, there is a need to create four levels corresponding to the four business areas, all at the same level. At last and at the final level of this hierarchy are all the products. It is possible to observe all this structure in the Figure 4.3.

▼ Company (CMP)	Business line (Company)
▼ Business unit (BU)	Business line (Business unit)
▼ Business area (BA)	Business line (Business area)
Product (PRD)	Product workspace

Figure 4.1: Workspaces

All the levels mentioned above can have their own associated strategy. This enables the association of the objectives and initiatives of the lower levels to the corresponding strategies of the higher ones, helping to clarify where the strategy for a certain product is integrated. This particularity is very important as it will permit all the team members to comprehend the role of each product/business area in the business unit strategy or in the company strategy, if applicable. Furthermore, it is also possible to assign each release or feature to a strategy (goal and/or initiative) demonstrating again the alignment of the product investments with the strategy previously defined [5].

Thus, it is perceptible that there is an architecture capable of logically defining the data model to be introduced in the software. This organisation can be seen in Image 4.2, which depicts the relationships between the different concepts of the program.

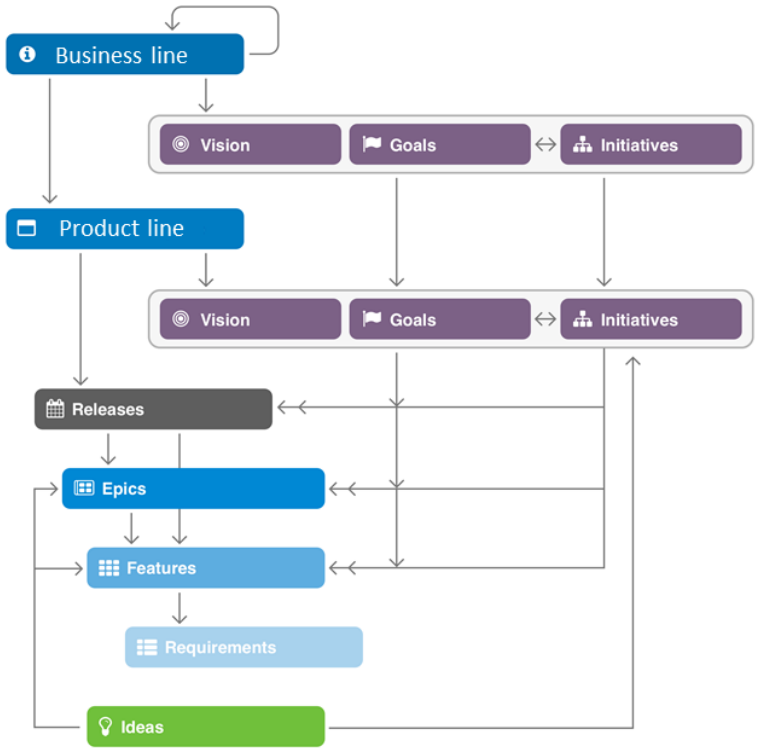

Figure 4.2: Aha! data architeture. Adapted from [5]

According to the organisation presented, the release concept represents a new version of the product or a new functionality which is being developed, to put it differently, aside from the strategy it is the level immediately below the products which will organise all the new actions on the projects, being possible to relate them to objectives and initiatives and also attribute status, progress, an owner, dates, among others. Subsequently, in the lower levels are epics, features and lastly requirements.

Regarding epics, they aim to group the features that share the same purpose, however, due to the structure of the company and the products, at this moment there is no necessity to introduce this concept.

On the other hand, features represent the fundamental units of work, in other words, they are children of releases and identify the capabilities that the product must contemplate in a determined context; they can also receive information including status, progress, type, assignments, goals, initiatives, score, among others.

Futhermore, the requirements have as their principal function to subdivide the work to be performed in the features through discrete steps, facilitating the organization of work and the

respective workflow monitoring.

At last, the ideas are promoted by the team and registered in the ideas portal of each product. It is possible to save information such as status, author, score, and others. All ideas are voted by the rest of the team and in case they are deemed viable, they might be promoted to features, epics or even initiatives, all of this reveals to be a quite attractive particularity as a starting point for the workshops mentioned in Chapter 3.

4.2 Software Implementation

Once in contact with the Aha! structure and understanding its functionalities, the next step is to incorporate the tool with the reality of the Service business unit. For this purpose, it is necessary to have a deep knowledge of the unit, namely its strategic plan, its products and the operation mode.

According to the Scrum methodology, discussed in Section 2.2, several meetings were held with the rest of the team, with the purpose of ensuring that the work performed was as effective and as close to reality as possible. Thus, the head of product management and other team members joined in the same meetings to ensure that the data was reliable, making the sprints fruitful and with high levels of performance.

In this initial implementation phase, there was a planning of the work to be developed during the sprints. Since this is an embryonic phase, and as the tool will have to be considered by management and later purchased, this initial task focuses on a first contact with the software for subsequent analysis of its role. This step is quite common, especially in large companies, where certain decisions require a coordination with the rest of the structure and subsequent acceptance by upper management, since it might be a tool to be implemented in other business units. In other words, in this phase the tool will be mainly applied to a specific product allowing a more objective contact and later its performance will be evaluated in cooperation with EFACEC's management.

4.2.1 Workspaces architecture

The workspace was organised according to the architecture explained above. Consisting of four main levels. The highest level of the structure represents the enterprise.

Next, at the level immediately below is the business unit and its children, the four business areas of the Service unit.

Finally, the base of the architecture contains all the products grouped by their respective business areas.

At this point, only information concerning the Service was introduced, since this project was conducted in the scope of this universe. Subsequently, if the tool is accepted and integrated in the company, the software architecture would be able to support all business units and their respective areas and products.

It is possible to visualise the whole configuration described in Figure 4.3.

▼ EFACEC (EFC)	Business line (COMPANY)
▼ Service (SRV)	Business line (Business Unit)
▼ Physical Asset Management (PAM)	Business line (Business Area)
Power Transforemers (PT)	Product workspace
Distribution Transformers (DT)	Product workspace
Mobility (MOB)	Product workspace
Switch Gear (SG)	Product workspace
Rotating Machines (RM)	Product workspace
▼ Digital Asset Management (DAM)	Business line (Business Area)
Diagnosis RM (DRM)	Product workspace
Diagnosis PT (DPT)	Product workspace
Diagnosis DT (DDT)	Product workspace
Diagnosis SG (DSG)	Product workspace
▼ Upcycling & Recycling (UR)	Business line (Business Area)
BioUP (BIOUP)	Product workspace
Forensis (FORENSIS)	Product workspace
REUP DT (REUPDT)	Product workspace
REUP PT (REUPPT)	Product workspace
REUP Batteries (REUPBAT)	Product workspace
▼ Integrated Solutions (IS)	Business line (Business Area)
MobiS (MOBIS)	Product workspace
eHUBS (EHUBS)	Product workspace

Figure 4.3: Service workspaces

4.2.2 Product workspace

As previously mentioned, only one example of the application of this software was developed. The choice for this example falls on the product workspace "Diagnosis SG" which pertains to the business area "Digital Asset Management", however, some examples were also developed to illustrate the strategy referring to the higher levels, including the levels "Service" and "EFACEC".

This example is for posterior presentation and analysis with EFACEC management. In this context, all the work developed will be presented in the EFACEC technology workshop. The objective of this workshop is to analyse and evaluate the different platforms of product life management of the different business units, with the purpose of choosing a single alternative and standardise the functioning of this process throughout the company.

Regarding "Diagnosis SG", which will be the example that will be in focus, it is a project to develop a monitoring and condition analysis solution for medium voltage switchgear (SG) assets. Thus, the main purpose is to develop a sensing model for digital asset management applicable to new Medium Voltage (MV) SG products (installation during manufacturing) and in operation (*retrofit* installation).

To understand the application of this software, all the information loaded will be presented along this section, as well as concrete examples of the resources that this platform provides and that can be used in the process of management of the life cycle of the products.

4.2.2.1 Strategy

The resources related to strategy allow users to easily identify information, including the positioning, strategic analysis, objectives, initiatives of the different levels of the EFACEC structure and also their interconnection, in other words, it is possible to understand how the initiatives relate to the objectives and how these interconnect with each other throughout the various levels. Furthermore, it will also be possible to relate the different features to their respective objectives, permitting a contextualization of the motive and the positioning that a particular feature will occupy.

Thus, there is a wide variety of possible fields to be filled in, such as:

- **Vision:** It allows a simple and generalised vision of the involved level, to put it in another way, by accessing this tab the user gets a general framing of the entity's purpose.

- **Strategic model:** Templates can be created or can be used templates provided by the tool that reflect already known models, such as the "Business Model Canvas", "Lean Canvas", "SWOT Analysis", "Porter's Forces", and others.

- **Positioning:** Allows an overview of the level's positioning regarding customers, company and product differentiators, slogans, etc.

- **Personas:** Information regarding the target audience, from market sector, number of assets, influence, relevant files, and others.This field has the particularity of being accessed by the levels directly below the one it was initially associated, to put it differently, if a certain "Persona" is associated with the "EFACEC" level all levels will have access to it, whereas if it is associated with the "Digital Asset Management" level only the lower levels connected to it will be able to visualize it.

- **Competitors:** Information regarding competitors such as number of employees, revenues, customers, growth rate, files, details about the products, and more. In this section the visualization logic described in the previous point also applies.

- **Goals:** Objectives related to the level in focus, being possible to assign a success metric, a time frame, a status, a progress, and even locate them in a two-dimensional matrix, where the vertical axis is the business value and the horizontal axis is the effort required, enabling the objectives to be related to each other in a chart.

- **Initiatives:** Efforts that help achieve the goals, being possible to assign this same relationship, a status, a progress, a time frame and exact dates (start and end).Similarly to the previous point, it is also possible to observe them on a chart according to the same axes.

Concerning the field of vision, examples have been placed at all levels of the architecture as can be seen in Figures 4.4, 4.5, 4.6, 4.7.

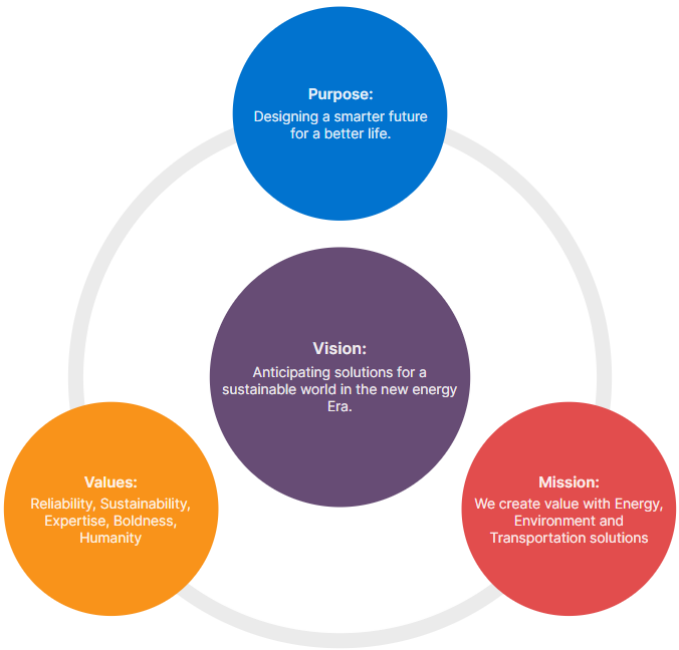

Figure 4.4: EFACEC Vision

Figure 4.5: Service Vision

Figure 4.6: Digital Asset Management Vision

Figure 4.7: Diagnosis SG Vision

Note that all the fields shown are configurable, both in the display structure and in the component name.

At the level of strategic models a SWOT analysis was developed regarding the Diagnosis SG, Figure 4.8.

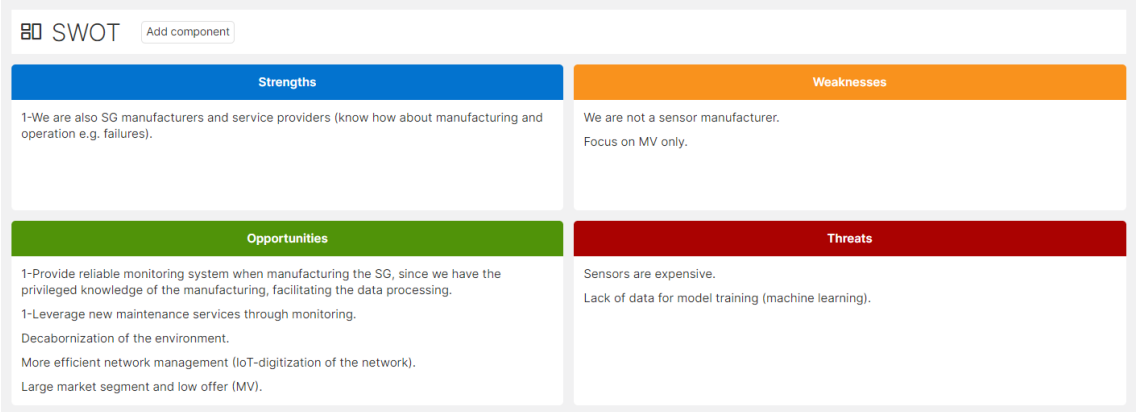

Figure 4.8: Diagnosis SG strategic model (SWOT Analysis)

On the other hand, no example was created for positioning due to the limited time of this project and the lack of existing information. However, similar to the strategic models, it is possible to create several positionings for each of the levels according to the user's preferences, for instance one product can have several positions for different projects. In addition, one more time, all fields are customizable.

Regarding the field personas, as explained earlier, it is necessary to have some concerns about the level where to place a particular customer. In this specific example, since it is a client that is transversal to different business areas, focused on the SG, its data has been placed at the Service level, enabling the access to its information through any of the business areas. The example is represented in Figure 4.9. Once again, all fields are customizable.

Figure 4.9: Example of a customer located at the Service level

On the other hand, the competitors are located in the product section "Diagnosis SG", since this information is quite specific to this type of product and cannot be reused in other business areas. An example of a competitor is shown in Figure 4.10.

Figure 4.11 shows a radar that enables us to compare all competitors, according to the logic of Gartner's Magic Quadrant. This has the axes "Ability to execute" and "Strength of vision" providing a graphical competitive positioning [39].

To evaluate the various competitors, according to these axes, criteria were created allowing for a standardization of the evaluation. For the "Ability to execute" axis, the following criteria were considered: The size of the company; The markets where it operates, which in a company that is positioned in several markets representing a competitive advantage through experience in different geographic areas with different/diversified exploitation practices; Finally, a more specific criterion of this product, The production or not of sensors and its market. This last criterion is quite complex, since four different cases were identified, such as being a producer of sensors in abundance in the market (1), being a producer of sensors in which its supply is limited in the market (2), not being a producer of sensors in abundance in the market (3) and not being a producer of sensors with limited availability in the market (4). Criterion 1 is not a particularly advantageous scenario, since this sensor is sold on the market by several entities and the probability

of acquiring it at low cost is high, thus its production does not represent added value for the company. Criterion 2 is considered the best case, since the company is a producer of a sensor that may have inflated costs due to its scarcity on the market. Criterion 3 represents a positive example, as the company is not a producer of a sensor that is abundantly available on the market and can be purchased at low cost. Criterion 4 represents the worst scenario, since the company is not a producer of a sensor that is scarce on the market and is exposed to the prices charged by its few suppliers. All these cases and the respective evaluation (1 refers to the worst scenario and 5 to the best scenario) are presented in Figure 4.12, where "P" symbolizes that the company is a producer, "$\bar{P}$" that the company is not a producer, "A" that the sensor market is wide and "$\bar{A}$" that the sensor market is scarce. Concerning the "Strength of vision" axis, the following criteria were associated: Market segment, where companies position themselves, in other words, it is considered that the completeness of vision of a company is stronger if its product is oriented to the MV market segment, since this is where EFACEC is betting and it is the one that presents the least solutions for customers; Product differentiators, to put it differently, technical specificities that enhance the product, such as the use of innovative technologies.

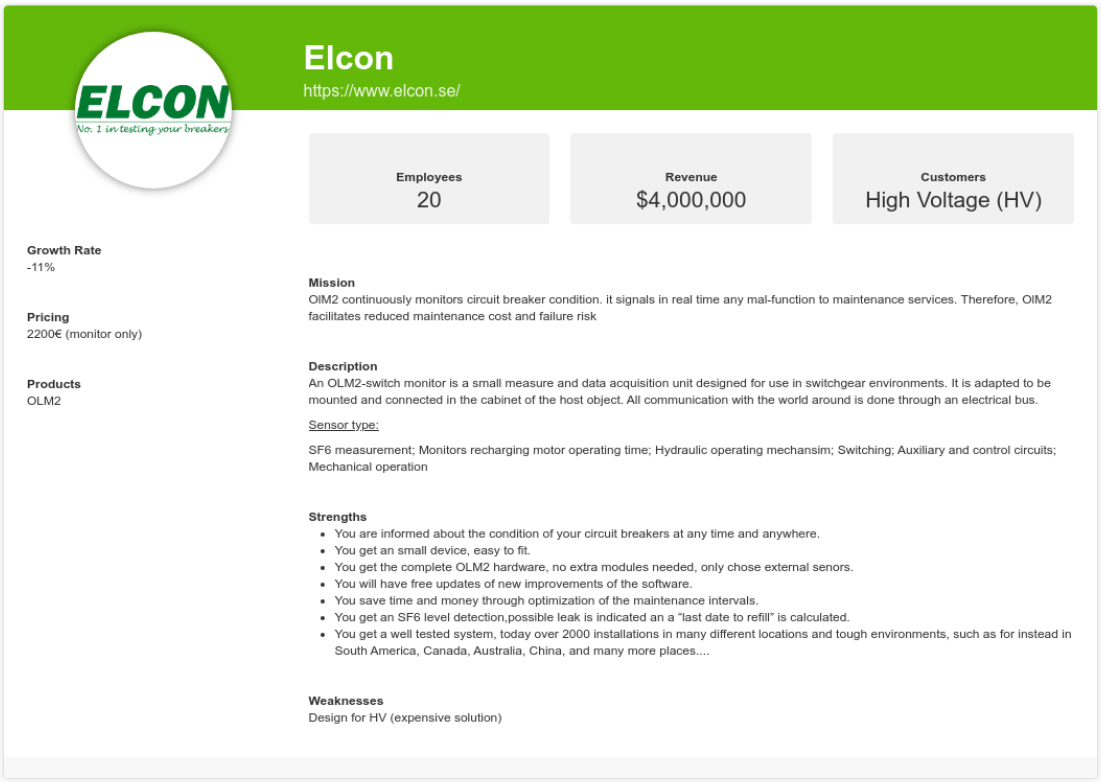

Figure 4.10: Example of a competitor located at the Diagnosis SG level

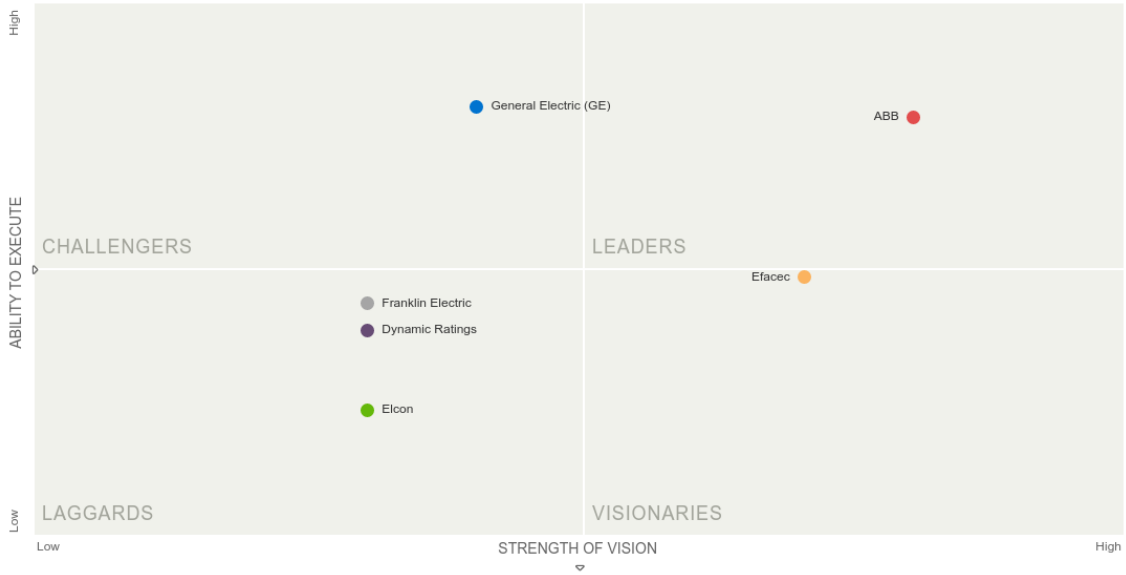

Figure 4.11: Gartner Magic Quadrant focused on competitors (Diagnosis SG level)

	A	$\overline{A}$
P	2	5
$\overline{P}$	4	1

Figure 4.12: Cases and assessment of the criterion "The production or not of sensors and its market".

The objectives, as previously described, are related to the level in which they belong, although they can be later associated with higher levels, in other words, it is possible to connect the objectives of a lower level to the objectives of higher levels. Furthermore, it is also possible to visualize through a matrix (Effort/Value) the objectives of a level, giving the perception of what value the objective will translate into the business and what effort it will require to be achieved. These particularities demonstrate not only a logical relationship between the objectives of different levels, but also enable the user a highly effective and reliable framework with the strategy of the level in consideration.

In the example in Figure 4.13, it is possible to observe the objectives of the "Diagnosis SG" level. Regarding the business growth objectives, as a success metric, it was placed the expected revenue (accumulated since 2022), the status is "Not Started" in all and the association to the "Increase Revenues" objective of the "Digital Asset Management" level. The information fields filled in the objective "Increase Revenues" were very similar to the previous one, being the success metric the "Product Launch", to put it simply it is considered that the acquisition of the necessary knowledge was achieved when the product is launched. Finally, this objective is related to the

"Knowledge Acquisition" of the "Digital Asset Management" level. Lastly, the objective "Asset management Service leverage" is the source of new business opportunities, for instance the detection of a failure that leads to a new business opportunity in other business areas of the Service unit. The success metric is approximately 10% of monitored assets. The status of this objective is "Not started", since it can only be executed after the product starts being commercialized. Finally, it is linked to the "Annual Revenue Growth" goal of the "Service" level, following the logic described previously.

Figure 4.13: Goals of the Diagnosis SG level

Regarding initiatives, in the context of this product only one "Design a technical and commercial offer" was identified, which in this case is design a technical and commercial offer of Digital Asset Management (DAM) for other Assets High Voltage (HV), MV and Low Voltage (LV) switchgear. With the status "Some progress" and linked to the identical initiative at the "Digital Asset Management" level.

4.2.2.2 Releases, phases, milestones and features

The product "Diagnosis SG" is a new project of the DAM business unit. Due to this reason, at this moment it will have only one release "Diagnosis SG V1.0" which will have associated phases, milestones and features. This release is currently under development and due to changes in the strategic part, there will be place for modifications in the format that was outlined, which will be reflected in its schedule (presented in Section 4.2.2.3). Also in this release, there is the link to all the product level objectives as well as the respective initiative.

Respecting the phases, their main purpose is the organization of the releases, functioning as work containers within the releases. On the other hand, milestones are important dates in the project that justify being highlighted. Both types can be associated with To Do's or features, enabling subsequent management of their progress.

Finally features can represent everything that has to be done to achieve the strategic vision, however, in this case features were associated with a technical character that takes place in the project development phase. All features could have status, score, progress, type, dates, assigned person, requirements, and can also be related to goals and initiatives.

With all these concepts as background the following phases were created:

- **Review product strategy:** With the Service strategic plan in the background, review this plan and establish the strategy for the "Diagnosis SG V1.0" release, through the workshops described in Section 3.2. At the end there will have to be a TRM proposal and its consequent validation.
- **Prioritize ideas:** Ranking existing ideas regarding the product in question, either from clients or from the team.
- **Add engineering requests:** Request the engineering team to provide technical specifications for the project.
- **Define included features:** Define which features will be officially included in the final product and confirm the respective requirements.
- **Development:** Development phase of the project, in other words, development of the features that have been established.
- **Review release with product team:** Review if the requirements of the developed features correspond to the idealized and also if the final product is viable. If non-conformities are found, the process will have to return to the most convenient phase to solve the problem.
- **Proof of concept:** Testing of the developed solution in a real environment, which may be on the client's site or at EFACEC's laboratory.
- **Communication and marketing plan:** Development of the communication plan (internal/external) and marketing of the project.
- **Support documentation:** Development of all project support documentation, both for the team and for posterior use by the client.
- **Sales and Support training:** Training oriented to the product specifications, in order to qualify the sales and support teams.

In this project it was only necessary to create one milestone "New product launch" which marks, as the name indicates, the launch of the new product on the market.

Finally, some features have already been defined by the team that will be developed during the development phase of the release, these features, together with the score (upper right corner), status (lower left corner) and type (lower right corner), are represented in Figure 4.14.

The score can be calculated through several criteria present in a customizable scorecard, however, due to time constraints, it was not possible to complete this step. The status could be one of the following predefined examples: "Under consideration", "In design", "Ready to develop", "In development", "Ready to ship", "Shipped" or "Will not implement". The type can also be one of the following predefined examples: "New", "Improvement", "Bug fix" or "Research". Note that these examples can be modified according to the user's preferences.

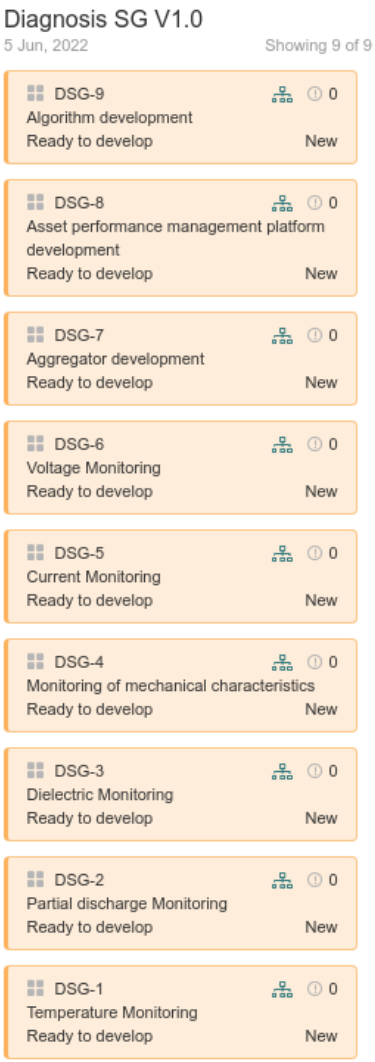

Figure 4.14: Features of the Diagnosis SG level

4.2.2.3 Roadmap

Besides what has been described by this point, the tool also allows extrapolating the planning to a graphical presentation, similar to a Gantt planning. This feature is very important as it facilitates the planning phase, both in terms of development and as well as in the presentation to an external person unfamiliar with the process. Therefore, it is possible to visualise the planning of this release in Figure 4.15.

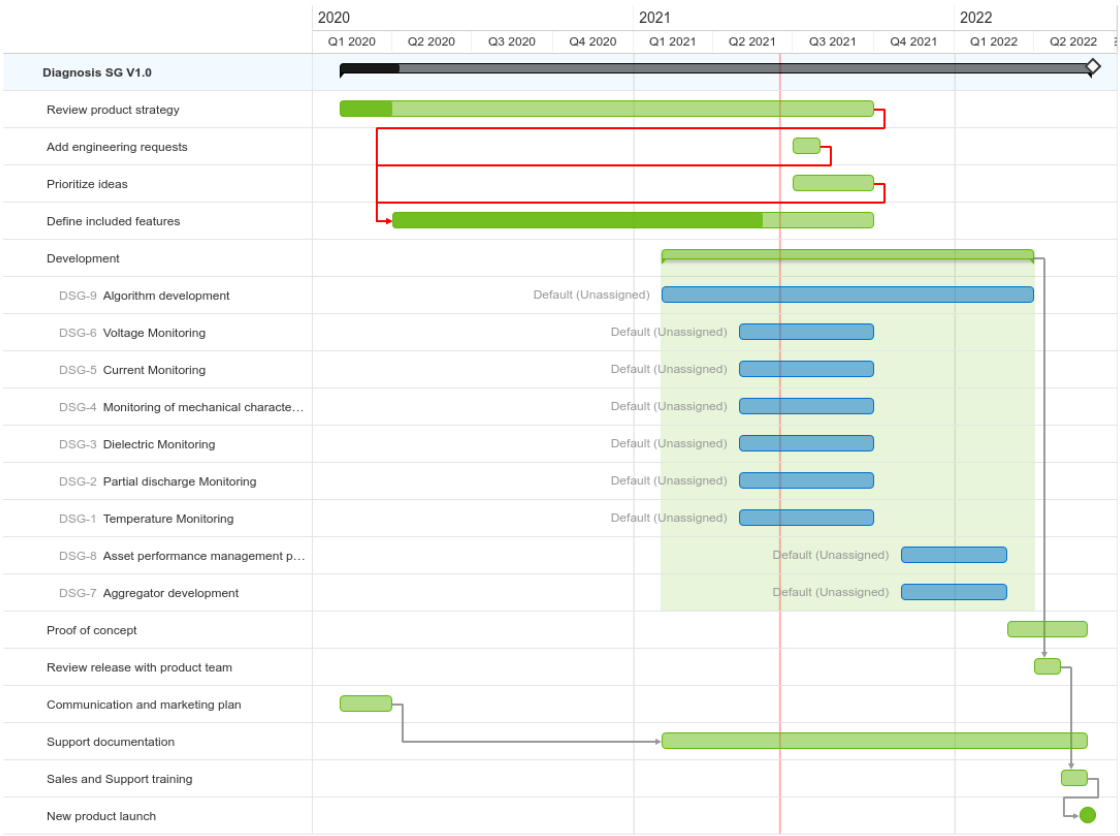

Figure 4.15: Gantt chart of the "Diagnosis SG V1.0" release

Regarding this planning, similarly to what was previously mentioned about the strategy change, it is possible to verify that there is a readjustment regarding the initially planned dates, to put it differently, it was necessary to extend the three initial phases and the "Define included features" phase, which should only start at the end of the three previous phases. Thus, all these phases was extended and will happen in parallel, with an extra care in the communication of the various actors as a mean to prevent communication failures.

The "development" phase begins during the "Define included features" phase, since as the features are validated their development can begin.

The proof of concept is planned to start during the final development phase, and will be executed on the customer site until the product is released.

The "Review release with product team" can only start after the end of the development phase. Its duration is predicted to be one month, and in case there is any opportunity to improve in the developed product it will be necessary to modify the planning, since it is necessary to introduce the setback in the planning. After this last phase finishes it begins "Sales and Support training" that will culminate, finally, in the product launch.

Finally, the "communication and marketing plan" starts at the beginning of the project and lasts for two months. After the end of this stage, the "Support documentation" stage may begin, which lasts until the launch of the product.

The example depicted above is very detailed, referring only to the planning of one product. However, the "Aha!" tool also allows the development of roadmaps involving more than one level, allowing a comprehensive overview of all planning from several levels, including company, business unit, business area or even product level. As only one planning example was built, it is not possible to present a complete roadmap seen from a top layer comprising more than one product.

It is also possible to build strategic roadmaps, allowing to chronologically situate and relate all the tier initiatives, however, as in this example only one initiative was planned, the roadmap will not exemplify a case with real interest.

4.2.2.4 Release Template

Also, regarding Gantt Chart, it is possible to systematize their configuration to ensure coherence between the different releases that have a similar action plan. Thus, it was created a product launch template containing the phases, milestones, their dependencies and to do's, customizing the way of working in the business unit. This template is present in Figure 4.16 and may be readjusted according to the needs of the release in consideration.

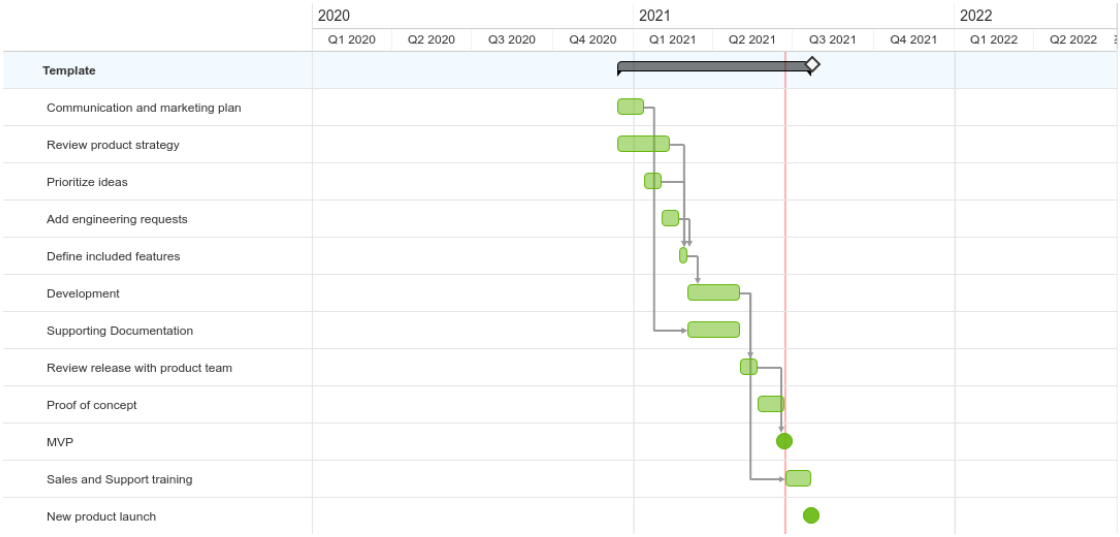

Figure 4.16: Gantt Chart template of releases

4.2.2.5 Presentations and Dashboards

Another important advantage of the software is the ability to create presentations and dashboards. Any view within the platform can be automatically exported either as an image or directly as a presentation for a meeting with collaborators, which greatly facilitates the treatment and presentation of information. Regarding the dashboards, it is also possible to develop charts aggregating different types of information that allow the monitoring, namely of the product development phase. After developing it is possible to join them, creating the dashboards.

4.2.2.6 Imports

All the work was developed in a free trial version, since the tool has yet to be acquired by the company. Hence, the fact that the software includes the option of importing information reveals to be very important for the sustainability of the work developed. To this end, a large part of the data loaded during the development of this dissertation was saved in .csv files, to be later imported into EFACEC's official licence, namely features, initiatives, releases and features. The remaining information was saved in .png format, enabling the posterior visualization of the information of interest.

4.3 Results validation

Once this first contact with the "Aha!" software had been completed, it was important not only to understand its contribution to EFACEC, but also to observe the impact of the digital transformation methodology presented in Chapter 3.

Regarding EFACEC's contribution, in parallel with this project, an initiative is underway to standardise the PLM process between the different business units. To this end, a meeting was organised on the 16th June, attended by several elements (more than 25 people) affected in this process belonging to the different business units. As this work was developed within the scope of this process (PLM) in the Service Business unit, it demonstrated to be relevant to present and demonstrate it during the meeting, as this tool has a high probability of being adopted by the entire EFACEC structure. Thus, a 45 minute slot was dedicated, firstly to introduce the methodology and then to demonstrate the structure and the work done in "Aha!" to the directors and product owners of the other business units. Following the meeting and the presentation of the various tools used by the business units, it was decided by the directors to adopt the tool demonstrated in this project throughout EFACEC.

Concerning the impact of the methodology, the best method to verify it is to make a new evaluation of the technology degree of this process considering its new configuration. It should be noted that this evaluation should respect all the concepts previously analysed in Subchapter 3.1, for instance the evaluation criteria, the color code and others. Having this in mind, it is possible to visualize the evolution of the technological degree in Image 4.17.

Initial assessment	33%		Final assessment	59%	
Team Communication	2,75	Email 2 (50%) Teams 3,5 (50%)	Team Communication	3,45	Email 2 (20%) Teams 3,5 (30%) Aha! 4 (50%)
Internal communication to EFACEC	2,75	Email 2 (50%) Teams 3,5 (50%)	Internal communication to EFACEC	3,65	Email 2 (10%) Teams 3,5 (30%) Aha! 4 (60%)
External communication to EFACEC	N		External communication to EFACEC	N	
Monitoring	2	MS Office 2 (50%) ERP 2 (50%)	Monitoring	3	MS Office 2 (25%) ERP 2 (25%) Aha! 4 (50%)
Document management	1	Teams 1	Document management	2,25	Teams 1 (50%) Aha! 3,5 (50%)
Technical tools	1	MS Office 1	Technical tools	3	MS Office 1 (50%) Aha! 5 (50%)

Figure 4.17: Digital degree evolution of the product management process.

Since the tool is not yet officially implemented either at EFACEC or at Service, the final assessment does not portray a photograph made at this precise moment, but rather a weighting of the capacity that the tool might be able to achieve if it were implemented at this time. However, as the example given suggests, it is possible to conclude that the tool is responsible for a significant improvement of the digital degree of the product management process. There is still some room for improvement, especially in the MOL and EOL sub-processes.

A different approach to understand the impact of the actions taken is through the updating of the three-dimensional matrix that reflects the technological level of the processes, as in the previous evaluation, this matrix was described in Subchapter 3.1. Its update is presented in Figure 4.18.

In this image, it is possible to verify that the actions adopted shape the process path, to put it differently, while the tool is implemented in the process, this will gradually approach to the quadrant "High level of technology and integration", it is important to point out that it is possible that as the tool is integrated in the company's reality, there might be disturbances in the path followed due to several factors, hence this case is a generic scenario.

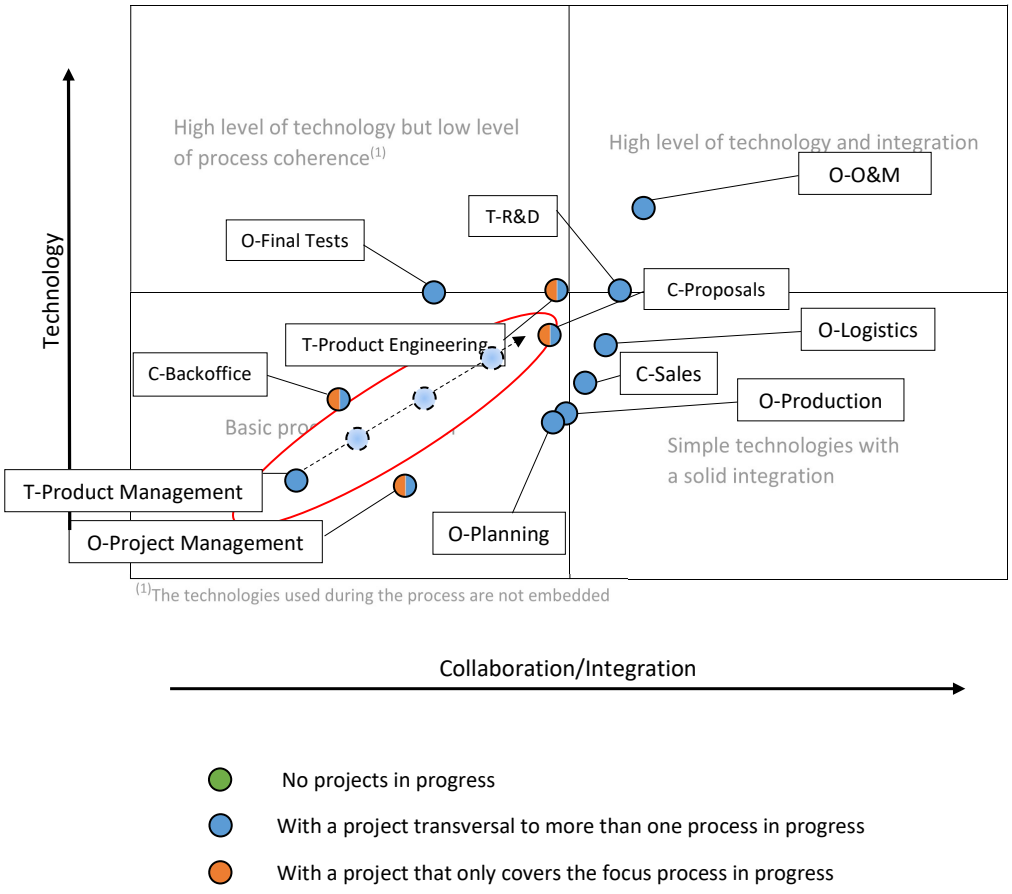

Figure 4.18: Update of the positioning of the Product Management Process in the Matrix of Digital Degrees

Chapter 5

Conclusions and Future Work

5.1 Conclusions

This project was divided into two major phases, initially the development and application of a digital transformation methodology oriented to the processes of a business unit, then, based on the result from the previous step, the implementation of its output.

The digital transformation methodology was developed from scratch, supported by existing literature. This methodology aimed at optimizing the processes of the Service business unit, based on their digitalization. To this end, the first step was to verify which process most needed technological support, and product management was identified. Thus, with constant communication between departments, a new study was made on the PLM concept, in order to obtain more effective results, since it was necessary to restructure the process. With the knowledge acquired in background, several evaluations were made with the aim of selecting a single tool that would support in the most effective way all or part of the product management process, in other words, all the actions performed had as main focus the achievement of the highest possible impact in the process in focus. Finally, the methodology indicated that the best tool to support the process, according to the different assessments, is the "Aha!".

Subsequently, it was necessary to implement the chosen software. As it was an acquired tool there was only space for the integration phase, since the development phase in this case was redundant. Firstly, it was necessary to make a deeper contextualisation with the tool. Once the knowledge about the software resources was acquired, the integration with the reality of the business unit was performed. Due to time constraints, a product was chosen to exemplify the potentialities of the tool, from the establishment of the workspaces to the elaboration of the development roadmap of the product used as an example. After the example was finished, as a way to validate the results, the evolution of the digital degree of the product management process was verified, in a scenario where the tool was implemented at this precise moment (with the experience obtained so far), and also a demonstration meeting of this same tool, in order to obtain the approval of the directors and the product owners of the various departments of EFACEC.

5.2 Future Work

This section analyses the work that could be done in the future, which for certain reasons, namely time constraints, it was not possible to perform.

On the one hand, in the first phase, as this is a methodology, it might undergo iterations whenever there is a significant change in the processes of interest, as exemplified in Section 4.3. Regarding the evaluation tools, since the methodology was developed to cover business processes from all areas, these do not require a significant further work.

On the other hand, the second phase of this project, software implementation, is where there is more space for future work. Since, due to time constraints, it was not possible to integrate the "Aha!" tool at EFACEC's environment, there was only time for a first contact.

Lack of time is also compounded by the need to authorise and purchase a software licence, procedures that prove to be quite lengthy, especially in large companies, as EFACEC.

As mentioned before (Section 4.3), after the software has been demonstrated and with the certainty that the tool will be adopted, it is necessary to proceed with its acquisition and subsequent alignment between the different business units, since the way they are structured is fundamental for the architecture of the workspaces.

Moreover, it is necessary to define the users and their authorizations to access the platform, as the information is critical, it is necessary to be very careful in this aspect, since it might result in information loss or even data alterations by other users that have no involvement with the unit.

Another aspect that is important to highlight are all the connections between the strategy of the different levels, since, as explained before, the connections between the releases/features and the initiatives/goals are extremely important as a mean to provide the team with a logical understanding of the products and their role in the company. As we are facing a dimension quite larger than the one portrayed in the example of this project, it is fundamental to have coherence in the various business units, not having, for instance, objectives or initiatives that represent the same meaning but with a different nomenclature.

As only one concrete example of the product "Diagnosis SG" has been developed in detail, it will be necessary to adapt it to the new information that arises at higher levels. Besides this, it is also necessary to develop all this work for the rest of the products of all the business units and keep the tool updated throughout its lifetime. In other words, this means working on the maturity of the tool throughout EFACEC, while keeping the notion of the architecture used in mind.

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