Business Process Modelling in the WCM 4.0 Achievement: Digitalization of a WCM Pillar in a Portuguese Company

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Abstract

The digital paradigm brings changes to markets and organizations need to adapt their strategy to survive. With a focus on achieving competitive advantage, companies must be aware of activities that add value, visualizing and analysing processes in a detailed way. Digitalization is an important concept when it comes to controlling the effectiveness and efficiency of processes, so companies are converting them in a technological dematerialized way. In this digital journey, business process management methods can be used to support the identification of sources of waste in processes and lean management can be applied to eliminate this waste. This paper describes a Portuguese case study where a company from the construction sector applies Business Process Management (more concretely the BPMN 2.0) to support the digitalization of one of the pillars of World Class Manufacturing, Cost Deployment, preserving the Lean Management philosophy that was already pursued by the company. The paper presents two models, the as-is model (process without a technological tool) and the to-be model (process with a technological tool) concerning the Cost Deployment process of the company under study, thereby reducing waste.

Keywords
BPMN 2.0; Lean Manufacturing; Industry 4.0; WCM; Digitalization

1. Introduction

We live in a world in which the market grows and changes day by day, and with this, comes increased competition between companies. Digitalization is an important concept when it comes to controlling the effectiveness and efficiency of processes, so companies are currently focused on exploring the opportunities offered by these technologies. To this end, factories need to focus on activities that bring value, thus eliminating waste, following the Lean philosophy approach. To get there, companies must understand the processes that are part of the value stream, thus emerging the concept of Business Process Management (BPM). BPM is the science to understand how work is done in a company, to ensure that results are maintained (Leopold 2013), in order to "improve agility and operational performance" (Chinosi and Trombetta, 2012). This "can have an important role in knowledge management, since they can convert the informal knowledge of processes to formal knowledge" (Salvadorinho and Teixeira 2021) while it helps "to assess the limitations of current processes" (Salvadorinho and Teixeira, 2021a).

Business Process Model and Notation (BPMN 2.0) was developed as a tool to describe and represent processes graphically, establishing a link between processes and systems to understand where and how processes can be automated (Arromba et al., 2019). Today, this tool, when combined with other methodologies can boost the digitalization on the shop floor (Salvadorinho et al., 2021). Besides, the "digitization of business processes makes it possible to automate and monitor their execution in real-time and thus to optimize them." (Schinle et al., 2020, p. 1). However, it must be borne in mind that for this digitalization to be successful, the already implemented Lean management (strongly applied in the Western industry) must be preserved (Salvadorinho and Teixeira, 2021a).

The present study aims to demonstrate how process modelling can help and support the implementation of World Class Manufacturing (WCM) tools (here with Lean Management integrated) in the digital world, to understand problems in processes and to identify opportunities for improvement. BPMN 2.0 will be the notation used to organize the company's processes, regarding one of the WCM pillars, Cost Deployment, to understand it well, in order to facilitate the identification of its flaws and, at the same time, to think about possible ways to improve and digitalize it. This notation will support the transition of the organization's process from cost deployment without digitalization to one that started to integrate industry 4.0 technology.

To achieve the desired objectives, the paper is organized as follows, Section 2 focuses on presenting a theoretical framework of the concepts that will be addressed in the practical case, clarifying concepts such as Lean Manufacturing, World Class Manufacturing (WCM), Lean 4.0, WCM 4.0, Business Process Management (BPM), Business Process Model and Notation (BPMN). Section 3 describes the Portuguese empirical study from a construction's company in which these concepts are applied, according to the BPM life cycle, explained in light of book de Leopold (Leopold, 2013). Finally, section 4 presents some final remarks as well as future work to be implemented in order to make the operation process of the operational excellence department as efficient as possible.

2. Literature Review

2.1 Industry 4.0: Main technologies and challenges

In the last two and a half centuries, the industrial sector has undergone four industrial revolutions. The last one, the Forth Revolution Industrial, raised the concept of "Industry 4.0", provides a new technological basis/paradigm for processes and products (Wankhede and Vinodh 2021). This revolution is represented by the incorporation of smart manufacturing technologies (Espinoza Pérez et al. 2022), therefore, industry 4.0 is defined as "the combination of emerging technologies and value chain organization concepts" (Kabzhassarova et al., 2021). This new digital paradigm will enable an interconnected environment where decisions are made by obtaining real-time data, influencing the industry as a whole, not only at the shop floor level, but also enabling the achievement of a sustainable factory (D'Orazio et al. 2020), while creating an opportunity and a challenge to the operators (Wankhede and Vinodh, 2021). Through the intensified use of these technologies that connect people and things "anytime, anyplace, with anything and anyone, ideally using any path/network and any service" (Wagner et al., 2017), it will be easier to transform mass production to mass customization (Siqueira and Davis, 2022), increase productivity, decrease costs, get better quality (Valamede and Akkari, 2020), decline unplanned downtime and raise the profits (Siqueira and Davis, 2022) to achieve the best possible customer experience.

Some authors have presented in their studies the most important I4.0 technologies, such as Internet of Things (IoT); Cloud Computing; Big Data Analytics; Cyber-Physical Systems; Additive Manufacturing; Virtual Reality and

Augmented Reality; Robotics, referring to them as the "key technologies for future and more agile production systems" (Wagner et al. 2017).

Industry 4.0 concept is being discussed across a large number of industries as a way to achieve the competitive advantage, but its implementation still has some challenges, in different fields (Wankhede and Vinodh, 2021). Some challenges pointed out in the literature are: (i) the high costs involved in implementation, since the company has to invest, in most cases, in new digital hardware, cybersecurity, licensing and maintenance of the system (Ghobakhloo and Fathi, 2020); (ii) the need to involve everyone in the organization, since the top management commitment to sustain the results after implementing the I4.0 technologies, to open-minded and skilled employees to use each new technology (Wankhede and Vinodh, 2021); (iii) the need to adopt the lean manufacturing as a prerequisite (Mayr et al., 2018); (iv) the need to understand, standardize and map the processes of the company, to more easily automate; (v) the need to have an action plan for the digital strategy to "smooth acceptance of Industry 4.0 in manufacturing organization" (Wankhede and Vinodh, 2021); and (vi) the need to have a "unified integrated digital ecosystem" (Ghobakhloo and Fathi, 2020, p. 16), to share the data between people, processes, technologies, machine controllers and database.

2.2 Lean Manufacturing and World Class Manufacturing

According to Mayr et al. (Mayr et al., 2018), the Lean concept can be considered as a prerequisite for the application and adoption of Industry 4.0. Lean Manufacturing means the creation of greater value for the customer, from the use of fewer resources, eliminating everything that does not add value, i.e. the waste (Marsikova and Sirova, 2018). It is also defined as the philosophy that enables organisations to achieve competitive advantage by increasing the efficiency and effectiveness of processes (Marsikova and Sirova, 2018).

To reach the objective of: maximizing customer satisfaction, minimizing delivery times, by reducing inventories, cycle times and process variability [17], the Lean methodology uses a set of tools and practices, such as Just-in-Time; Kanban; VSM; Kaizen and Hoshin-Karin, as well as action and motivation of employees (Valamede and Akkari, 2020).

According to Schonberger (Schonberger, n.d.), the term WCM (World Class Manufacturing) requires fundamental changes in industrial companies. This implies a constant evaluation of the competitiveness of manufacturing strategies to achieve the status of "world class manufacturer" (Haleem et al., 2012). WCM is a methodology based on Continuous Improvement, with the main purpose of delivering the best level of quality, at a competitive price to the customers (Flynn et al., 1997). To achieve this, it is necessary to eliminate all types of losses and waste, involving all members of the organisation and improving the standards and methods used in the company (Łyp-Wrońska, 2016). Some of the practices used in WCM include: Lean Thinking, Total Quality Management (TQM), Six Sigma, Autonomous Maintenance (TPM - Total Productive Maintenance), Customer Relationship Management (CRM) and environmentally responsible production (Haleem et al., 2012). These practices will contribute to the productivity of the company and, consequently, will enable the achievement of competitive advantage, contributing to a higher level of excellence (Novická et al., 2016). This concept is a rigorous method to attain operational excellence, in order to reach "zero accidents, zero rejects, zero failures and zero stocks" (D'Orazio et al., 2020, p. 1). This way, the main goals of tracking and disposal of waste and losses can be achieved (D'Orazio et al., 2020). The implementation of this methodology – WCM – is very similar to the implementation of lean, since lean is at the core of WCM operation (Chiarini and Vagnoni, 2015).

It should be noted that this philosophy is based on technical and managerial pillars, whereby technical pillars are: Safety, Cost Deployment, Focused Improvement, Quality Control, Workplace Organization Professional Maintenance, Autonomous Maintenance, People Development, Logistics and Customer Service, and finally Environment (Jha and WSEAS (Organization), 2012).

Cost Deployment (CD), being one of the technical pillars, is used to achieve the level of operational excellence, aiming to reduce and eliminate losses in a business environment (Jha and WSEAS (Organization), 2012), consequently reducing costs. To this end, it is performed the identification and analysis of losses and waste and their respective causes, both at the level of operational processes, as information processes (Novická et al., 2016).

2.3 Lean 4.0 and WCM 4.0

We are living in an ever-changing world, so organisations have concluded that they need to adapt continuously, in order to maintain their competitive advantage. Thus, it is perceptible that the integration of two major philosophies, Industry 4.0 and Lean Manufacturing, has been one of the ways to achieve this goal (Valamede and Akkari, 2020). The interaction between these 2 philosophies (Lean Manufacturing and Industry 4.0) to achieve the common goal of continuously adding value to production systems, resulted in the Lean 4.0 concept. The study reports in (Valamede and Akkari, 2020) presents five important characteristics of this concept: (i) the integration between process, devices and people (stakeholders); (ii) the reduction and/or elimination of waste; (iii) the flexibility of the supply chain; (iv) the automation, and (v) the analysis of solutions that promote continuous improvement.

During the continuous research on this concept, it became apparent that there are already several studies conducted to demonstrate the relationship that Lean Manufacturing and Industry 4.0 can interact and support each other, creating a win-win relationship. It is believed that industry 4.0 technologies have a lever on lean tools, for bringing them to a completely different level of excellence, concluding both philosophies complement each other (example in (Salvadorinho and Teixeira, 2021b), (Romero et al., 2019)).

According to (Ebrahimi et al., 2019), it is needed to make changes in the work regarding all the technical pillars of WCM to succeed the implementation of Industry 4.0 in industries that follow the WCM approach. Although this topic is not very well developed and studied in the literature, D'Orazio studied in (D'Orazio et al., 2020) how can I4.0 technologies "simplify the processes required by WCM" (D'Orazio et al., 2020). To achieve this, the impact I4.0 in each of the pillars of WCM temple (where the strategy to implement WCM is stated) was presented, wherefore concluded that "WCM may benefit greater accuracy, precision and reliability of information gathering thanks to I4.0 potentialities" (D'Orazio et al., 2020), and that the integration of this 2 philosophies can become a necessity to reach the competitiveness (D'Orazio et al., 2020). Also, according to Ebrahimi (Ebrahimi et al., 2019), the combination of the industry 4.0 principles (decentralization, real-time capability, virtualization, modularity, human aspect and interoperability) can support WCM tools and bring them to a whole new level of application. An example given in (Ebrahimi et al., 2019) is that: data analytics (technology from Industry 4.0) is a tool that can help and support the decision-making process through data collection in real-time.

It is stated in (D'Orazio et al., 2020) that "the plant managers assume the risk in taking a direction that may not be appropriate" through the use of non-adequately monitored data. Industry 4.0 can help the factory to use Cost Deployment to achieve cost savings by quantifying losses, providing a large amount of accurate and reliable data by using technologies that facilitate the data collection and consequently calculating losses costs using appropriate software. Therefore, it is possible to achieve truly information, regarding the plant, in order to make the best decisions.

2.4 Lean tools digitalization: How can BPMN help?

BPM (Business Process Management) can be defined as the set of "activities, methods, technologies and coordinated tools for a structured and analytical execution of processes aiming a continuous improvement" (Castro et al., 2020). This concept can, thus, be interpreted as a means to achieve the effectiveness and efficiency of a process (Lehnert et al., 2017), and aims to manage operational processes in order to increase agility and performance at the operational level (Chinosi and Trombetta, 2012).

BPMN (Business Process Model and Notation) emerged from the growing need of organisations to describe and represent their processes graphically. This is, therefore, a tool considered crucial in process modelling. In this way, BPMN can promote de description of diagrams that illustrate the aspects to be improved in processes, as long as coherence is guaranteed between what is executed and what is modelled, so as not to misrepresent reality (Chinosi and Trombetta, 2012).

According to (Schinle et al. 2020), "The digitization of business processes makes it possible to automate and monitor their execution in real-time and thus to optimize them." As already mentioned in the previous section, BPMN is a graphical notation universally used in process modelling.

BPMN is a tool that establishes a link between processes and systems, in order to understand where and how processes can be automated (Arromba et al. 2019).

After reviewing the literature on the integration of BPMN in the digitalization process, it was possible to verify that, BPMN notation can be the "language" of communication between the environment where the process is inserted and what is the computerisation of technologies (Winter et al., 2021).

Nowadays, it is easily noticeable that the world is constantly changing and only those who are flexible and open-minded to receive this change will survive (Valamede and Akkari, 2020). The same applies at the market level, where competitiveness is increasing day by day (Valamede and Akkari, 2020). There are many ways to achieve competitive advantage and digitalization and computerization of processes is one of them (Pietrewicz, 2019), therefore smart factories are trying to digitalize the value chain (Valamede and Akkari, 2020).

The use of lean tools, in general, is also one of these ways, which reveals itself capable of leveraging the efficiency of processes, focusing on what are the activities that add value, eliminating waste (Mayr et al., 2018). The integration of these 2 concepts, through the digitalization of lean tools ("forms the lean digitalization" (Jing et al., 2021, p. 2)), can bring them to a completely different level of excellence (Jing et al., 2021), through the achievement of process improvement (Chatzopoulos and Weber, 2021). According to Jing (Jing et al., 2021) "Lean digitalization is an improvement model that better integrates lean ideas, tools and means into the production management process of enterprises by using digital systems and technologies".

The digitalization of processes and systems needs a first approach of analysis and understanding of what needs to be digitized (Retamozo-Falcon et al., 2019). For that, BPMN, as mentioned before, can be one of the tools to use, since it allows modelling processes graphically (Chinosi and Trombetta, 2012). This tool is known "as a specific capability dedicated to process improvements" (Niehaves et al., 2014). BPMN could be used to map and document the implementation procedures of lean tools, so that they can be, later, digitized. After analysing the literature, it can be concluded that this topic has not been explored in the literature.

3. Case Study

3.1 Objectives

The study under analysis was developed in a company whose main activity is the production of products for construction. The company is present in more than 60 countries, enrolling 170 thousand employees around the world. The company applies a philosophy to the organization of its operations that can be translated into the following goal: highly engaged people are the strategy to achieve organizational operational excellence to provide the full potential of the processes and offer the best quality and service at the targeted cost (based on company's documents). To achieve operational excellence and attain WCM status, the organisation uses various methods, including "Lean Thinking", "Total Quality Management", "Agile", "Six Sigma", among others. The project will take place in the Operational Excellence Department, in the WCM area, more precisely in the adoption of one methodology, Cost Deployment, in order to conclude about the projects to be implemented next year, to achieve the objective of reducing production costs. Consequently, the company will become more efficient, which will contribute to a decrease in the consumption of resources.

This case study aims to demonstrate how BPMN can help the digitalization of WCM tools, reducing the room for mistakes and the time to apply them. To show this idea, the Cost Deployment process will be used, from the collection of information to the analysis of the results achieved with this tool, using BPMN 2.0 to show the process before (as-is model) and after digitalization (to-be model).

3.2 Methodology

The BPM life cycle was the methodology adopted to achieve the main goal stated before, i.e. how BPMN can support the implementation of WCM tools. This cycle has six phases to guide the processes analysis, according to (Leopold, 2013) : Identification; Discovery; Analysis; Re-Design; Implementation and Monitoring and Control, that are described next.

Process Identification: In this phase, to conclude on the process to be digitized, it was necessary to understand which set of processes would bring the most benefits by going digital. This way, an excel tool was developed to compare and evaluate the ICE (Impact, Cost, Easiness) index of each of them, through several indicators, such as: number of times it is used, time spent, number of people, among others. In this case, the Cost Deployment was the one that presented the highest ICE index.

Process Discovery: To organize the current state of the process, it was necessary to collect information about the process through meetings with stakeholders, through monitorization of operators during the development of their tasks, to obtain the required knowledge for the elaboration of the as-is model.
Process Analysis: Through the analysis of the current state of the process and of each of the tasks that are carried out, it became apparent that several improvements could be applied to mitigate or eliminate the wastes/problems.

Process Re-Design: With the identification of the possible solutions to implement, evaluating a range of different technologies with various purposes, the solution with the greatest impact was chosen, thus developing the to-be model. In this case, the solution was to use software that takes care of the repetitive tasks.

Process Implementation: In this step it is necessary to implement the necessary changes to solve the problem, taking into account two aspects: (1) changes in the activities performed by the process operators and (2) use of automation, to improve the process described in the to-be Model.

Process Monitoring: After the implementation of the process, it is necessary to understand not only if the improvements have happened, but also if they are being maintained. For this, a plan of audits was developed during the execution of the same process, twice a year.

3.3 Results and Discussion

As already mentioned before, the process identified, referred in this article as the micro-process was the adoption of a WCM tool, the Cost Deployment, in order to conclude the next year's projects to achieve the main goal of reducing the total producing costs, identifying the losses in the company.

First of all, a BPMN was developed to map the macro-process, understand where the department can act to applying the WCM methodology. The first stage is the preparation of Value Streaming Mapping (VSM), also taking measurements required to arrive at the Operational Process Indicators (OPIs) and Key Process Indicators (KPIs) values. With this information, an ideal Factory Model is created (in which the paths to be followed to reach the level of operational excellence are made explicit). Specifically, it is the company's long-term vision, where the best practices in operational terms and in terms of KPI values are defined, having as references the values already achieved by some of the brand's factories worldwide. The indicators calculated are then compared with the best achieved worldwide, thus carrying out a benchmark strategy. This comparison results in losses, which are a deviation concerning what is possible to achieve. At this stage, and by analysing the company's losses, a 3-year vision of the company is concluded (following the direction of the long-term vision defined in the factory model) and a roadmap is developed with projects to be implemented that will make it possible to achieve this same vision.

After the development of this roadmap, it is time to execute an X-Matrix, to verify if the projects to be implemented have an impact on the company's results, and in parallel the Cost Deployment is also executed. The Cost Deployment is developed to obtain information about the most significant losses in the company, to understand where savings can be made, and to evaluate potential projects to be implemented in order to eliminate these losses.

The X-Matrix defines: (i) the goals to be achieved next year (both in terms of savings and costs); (ii) the company's strategic axes based on the factory model; the tactics and projects to be implemented to reach the objectives (here we will have both projects resulting from cost deployment and brainstorming); and (iii) the objectives in terms of process indicators - KPIs and OPIs (OEE, setup time, for example).

After the selection of the projects, the management and implementation phase follows the PDCA (plan, do, check, act) methodology. In this approach, only chronic problems that need a more complex intervention are treated as projects, and depending on the complexity of the problem, they can be executed through a Standard Kaizen (1 month) or a Major Kaizen (100 days). Before, during and after the implementation of the projects, management of the projects is required, by the operational team. This process is divided into 5 main steps: initiation, planning, execution, monitoring and closure, which are developed based on the Single Agenda executed during Cost Deployment. Subsequently, a verification is made of the stabilisation of results for 12 months, both in terms of operating losses, financial results and CO_2, water, and waste levels. At the end of the year, a general review of all projects is carried out, analysing the results of that same year.

After presenting the Macro process of the EO department, it is now intended to show in more detail the Cost Deployment application process (micro-process), presented in figure 1, emphasising the strategy used to arrive at next year's planning, processing information in the excel tool. Several players are involved in this process: the operational team, comprising the operational, industrial and operational excellence departments; management control, consisting of the financial department; and top management, i.e. the general manager.

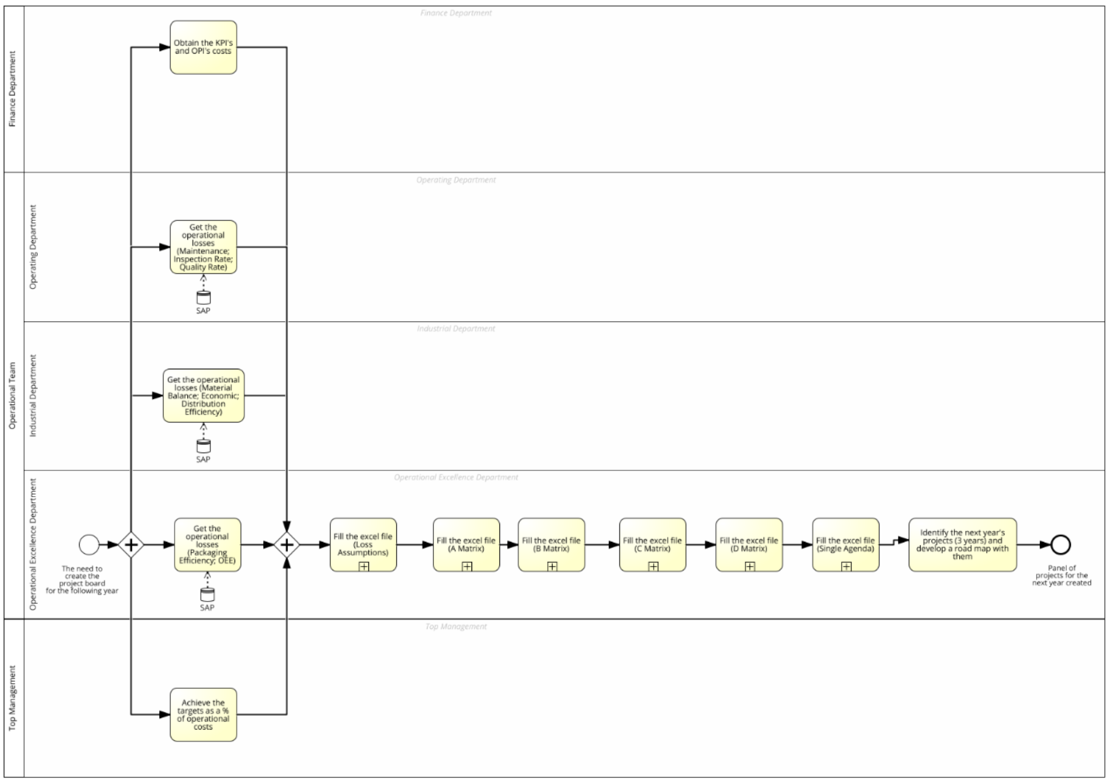

Figure 1. Cost Deployment Application Process (as-is Model)

Firstly, the collection of losses on the factory floor (operational) is executed by the operational team, being the industrial department in charge of collecting the losses related to: Material Balance, Economic, and Distribution efficiency; the operations department is in charge of collecting losses related to: maintenance, inspection rate, and quality rate; the operational excellence department is in charge of collecting losses associated to packaging efficiency; and OEE. Management control is responsible for obtaining the costs related to OPIs in the company's profit and loss account, and top management is in charge of defining the objectives as a % of operational costs, completed through what is achievable for the next year, with the vision of reaching the best practice values in the future (next year's objectives are different from the best practices, since they are not yet achievable). The steps for using excel, based on the Cost Deployment methodology, developed by the multinational, which allows it to arrive at the project plan for next year are:

i. Loss Assumptions → Setting goals for cost reduction, according to the company's KPI and OPI values;
ii. A Matrix → Identification of losses in each process;
iii. B Matrix → Relationship between causal and resultant losses;
iv. C Matrix → Loss estimation and stratification;
v. D Matrix → Identification and definition of projects, taking into account the ICE index and the impact on losses, CO_2, water and waste (identification of methods and tools);
vi. Single Agenda → Project Listing, Planning and Results (Prioritization);
vii. Next Year's Projects → Projects that cannot be completed next year are postponed to the following years

Once the identification and process data collection phases are completed, through the BPMN 2.0 utilisation, the process analysis phase follows, according to the BPM lifecycle. Process problems are identified more easily, once the mapping has been completed, since the activities, the links between them and the actors involved are analysed at the time of mapping. These improvement opportunities were found through involvement in the Macro-Process, understanding where the department can act in order to apply the WCM methodology.

Regarding opportunities for improvement, it is possible to highlight:

- the processing of information in Excel, in the adoption of Cost Deployment methodology, in order to arrive at the planning of next year's projects is time-consuming, unintuitive and with lots of room for mistakes;
- the analysis regarding CO2, water use and waste impacts is complex and, therefore, leads to a high level of errors.

At this point of the study, it was essential to understand and get into a more detailed discussion about how the cost deployment process will be improved through the utilization of Industry 4.0 technologies, to redesign the activities to move forward to the redesign phase.

After that being said, it was analysed the activities followed to achieve the main goal, already explained before. For that, it was discussed, for each activity, regarding the type of activity (to eliminate, to reduce, to maintain); the needed time to perform; and the person/machine that executes the task (that can be from operational excellence department, industrial department, operating department, finance department, and top management). The following scheme (Figure 2) shows this information.

BEFORE (AS-IS)			
Activities	**Time (min)**	**ELIMINATE/REDUCE/MANTAIN**	**Who perform the task?**
Cost Deployment	4210		
Operational losses	2400	MANTAIN	All Departments
OPIs and KPIs costs	480	MANTAIN	Finance Department
Targets as a % of operational costs	480	MANTAIN	Top Management
Excel	850	MANTAIN	Operational Excellence Department
Loss Assumptions	100	ELIMINATE	Operational Excellence Department
A Matrix	80	ELIMINATE	Operational Excellence Department
B Matrix	100	ELIMINATE	Operational Excellence Department
C Matrix	140	ELIMINATE	Operational Excellence Department
D Matrix	120	ELIMINATE	Operational Excellence Department
Single Agenda	240	REDUCE	Operational Excellence Department
Next year's projects	70	ELIMINATE	Operational Excellence Department

AFTER (TO-BE)	
Activities	**Time (min)**
Cost Deployment	3550
Operational losses	2400
OPIs and KPIs costs	480
Targets as a % of operational costs	480
Put data in S3	120
Next year's projects	70

Figure 2. Demonstration activities of the Operational Excellence Department Before and After the improvements

By analysing the figure above (Figure 2), it can be seen that Cost Deployment (before the improvements) needs at least 4210 minutes (approx. 9 days) to be done (the activities with '*' are part of the Macro Process that weren't improved in this study, so the time for that being done is not important to analyse at this stage of the study). In this way, the process was redesigned (figure 3) and will be explained below, in order to achieve improvements in the time and resources needed to establish the planning of next year's projects through the implementation of the software. The same players are involved in this improved process: the operational team, comprising the operational, industrial and operational excellence departments; management control, consisting of the financial department; and top management, i.e. the general management. It will be noticeable from the explanation of the flow of activities that many of those that were previously performed have been eliminated, as can be seen in Figure 2. This was because a digital tool was adopted that automated these tasks, and this is how the improved process was achieved. The interface of the utilized software can be seen in Figure 4.

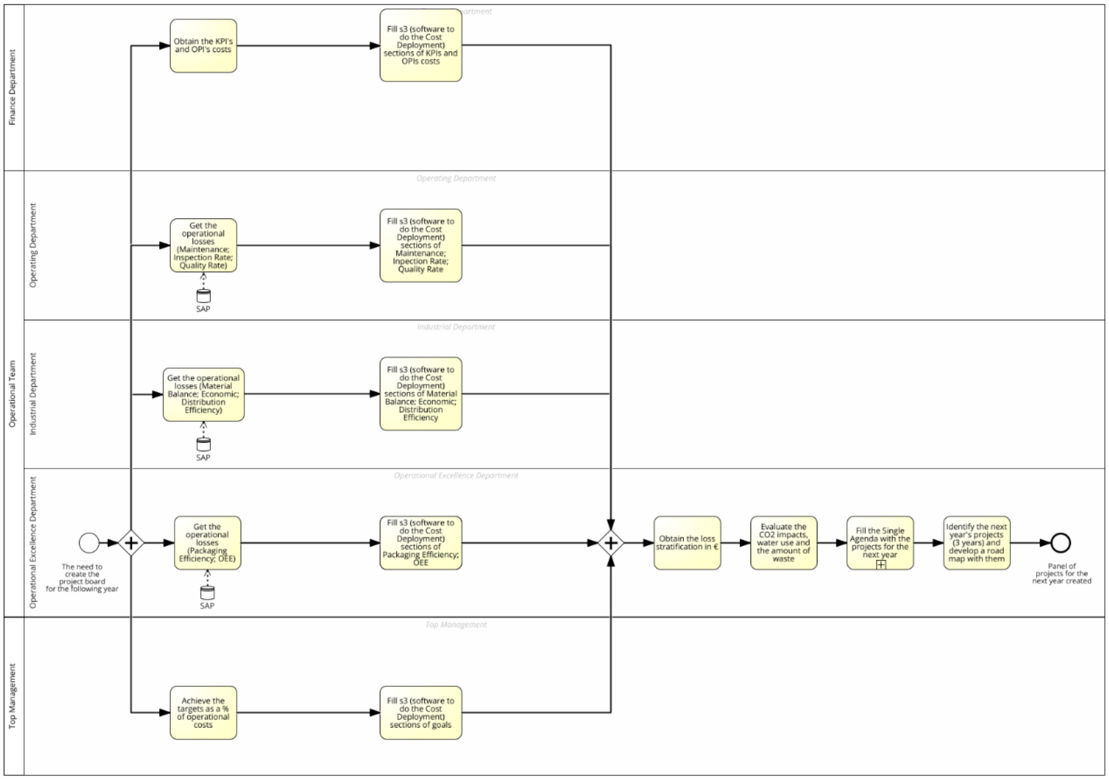

Figure 3. Cost Deployment Application Process (to-be Model)

Firstly, the collection of the losses, the costs related to OPIs in the company's profit and loss account and the objectives as a percentage of operational costs were achieved in the same way as explained in the process before the improvements (Figure 3). After that, it was time to fill the blank spaces in the software with this information. Next, the stratification of losses in euros was performed. As the next step was the assessment of the CO_2 impact, water use and the amount of waste, we had already gathered the data to start filling in the single agenda with the projects for the next year (was done the same way as in the process before the improvements), thus arriving at the panel of projects for the next year. The projects that cannot be done in that year, due to the lack of time and resources are organised in order to develop a road map (3 years).

These activities were also analysed and the resultant information was compiled in Figure 2 (right table).
By comparing the total time required to perform Cost Deployment methodology, by using s3 (software), it can be concluded that the company gains 660 minutes, which is the equivalent of 11h (approx. 1,5 days). This value represents 16% of the time initially needed. If a man has a cost to the company of 16€ per hour (approximately), not only with the salary, but also with health security, feeding subsidy and so on, and having in mind that 11 people are needed in both processes (before and after) during the filling phase of the excel, at least 3800€ will be saved, since these workers may be performing other activities and that CD is developed twice a year. Taking into account that the implementation was previously done by filling out and analysing several sheets, in order to arrive at the choice and scheduling of projects for the following year, it was possible to verify that it was really necessary to make changes in order to make it more effective and efficient. Thus, it was through this software that the problems encountered were solved, these being: time-consuming, unintuitive and with lots of room for mistakes and the information flow was not continuous. With the use of this technological tool that performed the repetitive tasks, and as can be verified by the improvements achieved, the information flow became continuous, and the obtaining of the results is achieved intuitively and instantaneously (figure 4).

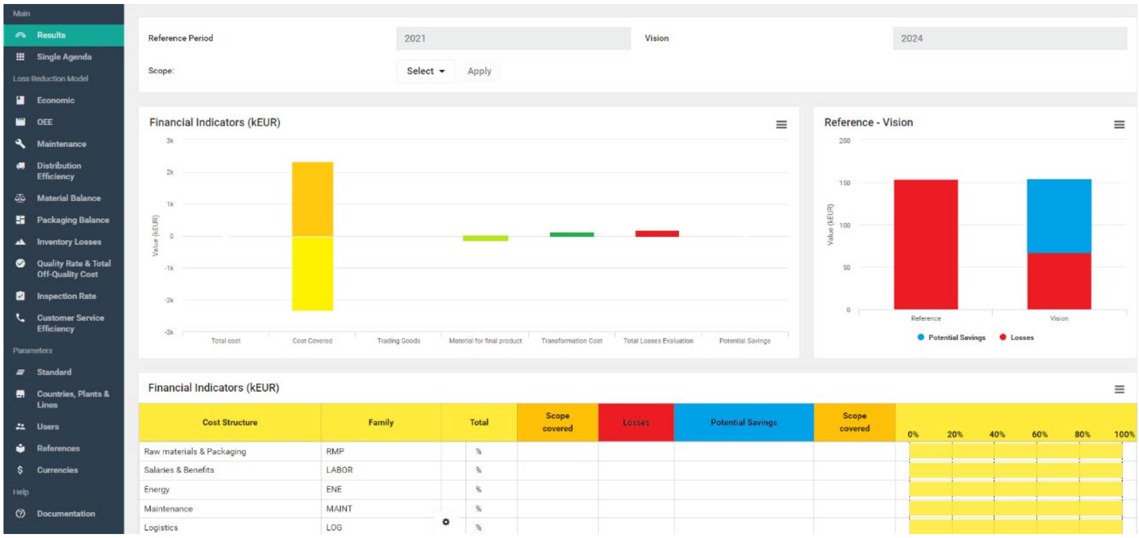

Figure 4. Software Interface

4. Final remarks and future work

Over the last few decades, it is well known that Industry 4.0 has brought companies a need to readapt to new markets, and therefore to incessantly seek competitive advantage in the marketplace to survive. Process optimisation is a strategy increasingly adopted by organisations through process modelling, using BPM, not only for mapping the process itself, but also the new context through the digitalization of it. This mapping will help as it facilitates process analysis, presenting itself as a useful way of understanding problems and flaws in processes in order to find opportunities for improvement, consequently implementing Lean tools to reduce or eliminate wastes and achieve the desired results. These methodologies/techniques, Lean and BPM, were addressed and presented in the study, to understand how these concepts can help the digitalization of WCM tools, reducing the room for mistakes and increasing process efficiency (less time to implement).

The notation applied to understand the processes, the activities performed, the people to whom the activities are assigned, and all the resources used was BPMN2.0. To reach the final objective, the BPM life cycle, explained in the methodology, was also followed. It should be noted that Industry 4.0 and its technologies were the basis for the process re-design, through the implementation of a software that contributed positively to the efficiency of the Cost Deployment process. This work promotes the digitalization of the organisation's processes, preserving what companies already have at their shop floor which is a lean shop floor management.

After explaining the whole practical case, it can be inferred that BPMN helped the digitalization of lean tools, as it allowed: the process analysis, getting to know the processes, people, tasks, systems involved, among others; understanding where to act, i.e., what are the critical points of the process; and also, understanding where it is possible to improve, where are the opportunities for improvement. In this way, it is possible to conclude that the company took advantage of the BPMN tool to digitize one of the WCM pillars, with integrated lean tools, and gained with this, time to implement this methodology. Furthermore, the company understood that it was necessary to digitalise processes, preserving what is already applied, the lean methodology. Additionally, it was perceived that there is very little literature that approaches this theme of digitalization of tools based on lean philosophy.

In the last section, two opportunities for improvement were presented. However, only one of them has been implemented so far. Therefore, the suggestion for future work is regarding the analysis of the CO2 impacts, the water use and the amount of waste is complex and, therefore, brings about a high level of errors. Therefore, it is imperative to adopt a program that quantifies these impacts.

To sum up, it is essential to invest in the digitalization of Lean tools, since it is somewhat consensual in the literature that a good lean shop floor promotes a better integration of Industry 4.0, which ends up referring to the advantages of Lean in the implementation of Industry 4.0. Beyond that, it is clear that the opposite also happens, I4.0 tools can bring lean, and consequently WCM, to a completely different level of excellence, through the digitalization of Lean tools.

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