How can management and process methodologies help to define a roadmap for digitization? A proposal based on a practical case

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Abstract

Companies have been forced to adapt quickly to the Industry 4.0 paradigm in order to obtain, or at least maintain, their competitiveness. Digital Transformation has been one of the ways that companies have found to adapt their processes, to make them as effective and efficient as possible. For this, there is an emerging need for methodologies that guide this digitalisation processes in companies that already operate with traditional management methodologies, capitalising on the effort that companies have already put into philosophies such as Lean Manufacturing. This article aims to propose a roadmap to monitor the digitalisation of processes based on traditional management methodologies (PDCA, SDCA and Lean) and processes (BPM and BPMN), also presenting a tool that supports one of the steps of this methodology. Aligned with this methodology and in this investigation context, a tool was also developed using Microsoft Excel, entitled DiYD (Do it Yourself Digitalization) which aims to help the digital transformation. This tool, based on a process-oriented language, was used to map the company's processes, facilitating the identification of their flaws and achieving opportunities for improvement. The construction of this roadmap (for the process of dematerialisation and digitalisation of processes) was based on a practical experience in the industrial context with the objective of contributing to the achievement of World Class Manufacturing status and operational excellence. In this way it is possible to fill the gap in the strategies for the development of digital transformation, integrating lean tools in its base.

Keywords
BPMN2.0; Lean Manufacturing; SDCA; PDCA; Digitization

1. Introduction

With the advent of Industry 4.0 many technological changes are taking place, and many challenges for organizations are emerging (Salvadorinho and Teixeira 2021b). Increasingly, companies have been focusing on the concept of digitization, as it has proven to be essential when it comes to increasing the effectiveness and efficiency of processes. However, in order to achieve success in this digital transformation, it is important to improve the processes even before going digital, by reducing the non-added-value activities, with Lean emerging as a solution in this context. It is perceivable that Lean was a wave in western industry, and since it worked so well, the future must involve preserving this stay, creating mechanisms to associate these tools to the digital paradigm, using Industry 4.0 paradigm (Salvadorinho and Teixeira 2021a; Turconi et al. 2022).

Nowadays, taking into account the current industrial revolution, the development of strategies that outline digital transformation is an important issue for beginning the adoption of industry 4.0 technologies (Shaykhulova and Selivanov 2021). According to (Bellantuono et al. 2021), there are several digital transformation models and roadmaps in the literature to support companies in their transition toward Industry 4.0.

Since "the digitalization can be assigned to the principle of standardization" (Dombrowski et al. 2017), and since the "digital transformation is not only a matter of technology and that the implementation of Industry 4.0 requires a complex change management process" (Maimone 2022), the digitalization process can benefit from Lean practices. This study aims to fill the gap of the lack of strategies to guide the digitalization process, leveraging the synergies of companies with other management practices such as Lean, more specifically PDCA (Plan-Do-Check-Act) and SDCA (Standardize-Do-Check-Act) practices. In addition, this work affirms the importance of industry 4.0 for World Class Manufacturing, i.e. the achievement of a whole new level of operational excellence. In order to achieve the objective defined, a case study that aims to propose a methodology to conduct digitalization projects in processes that benefits from the Lean approaches, will be presented. In addition, Business Process Model and Notation (BPMN 2.0) will be the tool that will support the organization of the processes, in order to identify opportunities for improvement even before the digitalization itself. To clarify how one of the phases of the methodology takes place, the processing of information in a tool developed in excel will be explained.

Thus, this article is structured as follows: section 2 focuses on presenting a theoretical basis of the concepts that will be touched in the practical case, explaining concepts such as: Industry 4.0 in the digitalization field; Lean Manufacturing, World Class Manufacturing (WCM), Lean 4.0, WCM 4.0, Business Process Management (BPM), Business Process Model and Notation (BPMN), PDCA, SDCA, Digitalization Roadmaps; section 3 describes the practical study in which these concepts are applied; and, in the end, section 4 presents the final remarks and the future work to continuously achieve the operational excellence in an organization.

2. Literature Review

2.1 Industry 4.0, Lean 4.0 and WCM 4.0: The digitization process

The fourth industrial revolution is seen as a new "completely automatized and interconnected reality" (Turconi et al. 2022). This connection resulting from data analysis in real time, is able to connect people, systems and objects, which will consequently contribute to the digitalization of the value chain, causing a radical change in the industrial environment (Kagermann 2015; Maimone 2022). Therefore, Industry 4.0 will make it possible to redefine processes by digitizing them (Salvadorinho and Teixeira 2020 2021a).

On the other hand comes Lean, a philosophy widely implemented in Western industry, which is characterized by continuous improvement through the constant elimination of activities that do not add value to the customer (Bittencourt et al. 2019), thus increasing operational performance (Tripathi et al. 2022). This philosophy can be used as a way to achieve success and the competitive advantage (Marsikova and Sirova 2018), and it can also be considered a pre-requisite for the implementation of Industry 4.0 (Mayr et al. 2018), through achieving the above objectives with lean, a streamlined and in-control process can be achieved, which can be described as an essential aspect for process digitization (Cifone et al. 2021). According to Kolberg et al. (2015) companies that have lean implemented have processes more standardized, more transparent and focused on those activities that add value (waste-free). As processes are simplified, it is easier to integrate Industry 4.0, moving it from science to practice, in the real world. Furthermore, it is possible to conclude that Lean tools can be digitized by using Industry 4.0 technologies.

As its stated in Tripathi et al (2022), the integration of these two philosophies through the connection between the

technologies, tools and principles can increase the operation excellence in all types of businesses. This integration can be called Lean 4.0 (Mayr et al. 2018).

Richard Keegan and Richard Schonberger used the Lean approach as one of the bases for the creation of the concept of World Class Manufacturing (WCM) (D'Orazio et al. 2020). This philosophy (WCM) is accompanied by the premise that there are no perfect processes, and there is always room for improvement (Łyp-Wrońska 2016). Currently there are several companies that bet in the analysis of the benefits of integration of I4.0 technologies and WCM philosophy, to achieve this competitive advantage (D'Orazio et al. 2020). In order to apply WCM system, is necessary a high level of precision and quantity of data, that can perfectly be assured by I4.0 technologies (D'Orazio et al. 2020; Ebrahimi et al. 2019). The same author D'Orazio, studied the impact of I4.0 in each WCM pillar, concluding that "the totality of the pillars can benefit significantly from an investment in I4.0 technologies."

2.2 Digitalization Roadmaps
It is perceptible from the literature that more and more companies are concerned with digital transformation as a way to increase their competitive advantage in the market (Gomes et al. 2020). However, this path towards the adoption of Industry 4.0 has proven to be complex (Hughes et al. 2022), where the biggest challenges in this transformation are the definition of the vision for the future and the establishment of a roadmap to follow this change (Zaoui and Souissi 2020). Therefore, while companies understand that this transformation is potentially advantageous, it is essential that they have a clear path to guide them in redesigning their processes (Gökalp Martinez 2021).

Based on the framework developed and explained by Issa (Issa et al. 2018), it is noticeable that there are steps to guide companies in implementing the industry 4.0 concept (phases for the roadmap creation process), which can be the basis for organizations to make their own digital transformation roadmap, since it is unique for each company. The phases for the roadmap creation process are: 1- Task Force Setup - At this stage the team is defined for the digitalization project; 2- Digitalization Assessment - In the meantime, the organization then moves on to understanding, through its members, where the technological gaps are in the information flow, as well as the missing sources of information and documentation; 3- Focus Definition - After the previous understanding it is essential to prioritize where it is possible and beneficial to digitize, thus defining key action points. Indicators are also defined, which allow monitoring and evaluation of opportunities; 4- Use Case Idea Generation - Once the focus of action has been defined, it is essential to go to each use case together with the operators to understand what the main problems and ideas for improvement are; 5 - Use Case Impact Estimation – This is a phase where an evaluation of each use case is done taking into account the indicators previously defined; 6 - Use Case Selection – In this final stage the use cases to be digitized are selected taking into account their benefits.

2.3 BPM and PCDA&SDCA to support digitalization
Business Process Management (BPM) is a methodology used in the management and modelling of processes, in order to analyze, improve and control them (Mehdouani et al. 2019). BPMN (Business Process Model and Notation) is the language used to "represent the graphical layout of business processes" (Chinosi and Trombetta 2012), in a simple way, so that it is easy for both users and experts in the area to understand what is being described (Arevalo et al. 2016; Chinosi Trombetta 2012).

The PDCA cycle also known as Deming's cycle, is an essential part of lean thinking philosophy (Kadir et al. 2019) and has as its main objective to achieve continuous improvement in all types of organizations, solving problems and implementing new solutions (Jagusiak-Kocik 2017). The 4 steps will be following described: Plan – Answers the question "What to do? How to do it?" (Novická et al. 2016); Do - It focuses on "Do what was planned" (Novická et al., 2016); Check – "Did things happen?" (Novická et al. 2016). In this phase is where it is verified if the solutions implemented in the previous phase really brought positive results. If everything goes as expected, it moves on to the next step - Act. If not, it returns to the first step – Plan (Jagusiak-Kocik 2017); Act – "How to improve next time?" (Novická et al., 2016). This last step concerns previously implemented solutions, standardizing and monitoring the activities of that solution if the expected results have been achieved, verifying periodically if is everything as the standard (Jagusiak-Kocik 2017; Novická et al. 2016).

The different stages of the SDCA (Standardize, Do, Check and Act) cycle are the same as those of the PDCA, only differing in the first stage, which is called Normalize and where the standard to be implemented is created (Knop and Mielczarek 2015; Liedtke 2014). It should be noted that in the last stage, Act, action is taken according to what has been learned from the standard, thus deciding whether to abandon, modify or continue with this standard (Liedtke

2014), and in case of any deviation, corrective action is taken (Knop and Mielczarek 2015). As stated by Liedtke (2014) and according to Ishikawa, "A standard that has not been reviewed, is a standard that is not being used".

Digitization can be understood, in a first approach as the process of transforming manual tasks into automatic ones and "analogue data" into digital information. Business Process Management (BPM) contributes to this transformation, as it integrates the data, functions and tasks of a company (Lederer 2019). By analyzing the literature, it "seems to agree the digital transformation and innovation and BPM connection is almost mandatory" (Gomes et al. 2020), since the digitization of the processes' company needs to start this transformation by analyzing them and concluding which ones benefits the most from this new paradigm, i.e., the digitization (Retamozo-Falcon et al. 2019).

According to the literature, and as previously mentioned, the PDCA cycle is used in continuous improvement for the implementation of new solutions (Kadir et al. 2019) and the SDCA cycle is used to stabilize and standardize the already improved processes (Castro and Teixeira 2020). Since the digitization of processes is something that can be summarized as taking the current processes and adapting and bringing them to the digital world, i.e., making a change, an improvement/ new implementation, using technology, the PDCA and SDCA cycles can support this change and adaptation of processes to the digital paradigm.

3. Empirical Study
3.1 Goals and Methods
The practical case under analysis was developed in the WCM area of a Portuguese company, belonging to the construction sector, that is present in 70 countries. This company applies a WCM philosophy to its operations, in order to achieve operational excellence.

Cost Deployment is one of the pillars of WCM and was developed in the company with the intention of finding the projects to implement in the forthcoming year, to reduce the company's losses. However, most of the projects could not be implemented due to lack of resources, and after evaluating the Factory Model (ideal factory model, which explains what should be treated to get to the ideal – considering for example equipment, maintenance and quality), it was perceptible that this lack of resources concerns with human resources. People were spending a considerable part of their time on repetitive tasks, using paper, email or excel, that do not add value to the customer. To mitigate or eliminate this problem, it was concluded that some of these processes should be digitalized, with the aim of freeing up people in the data and information management processes, to enable them to spend most of their working time adding value and managing change in accordance with the Company's objectives, in an agile and transparent manner.

The case under analysis has as main objective to propose a methodology/roadmap to support the digitalization process using lean tools to organize the steps that support this digital transformation. Aligned with this roadmap, a support tool was developed, which intends to help this digital transformation, using a process-oriented language, the Business Process Model and Notation BPMN, to clarify the company's processes, and facilitating the identification of their flaws and reach improvement opportunities.

Action research methodology was applied since all the development was made with the researcher inserted in a digitalization team, being immersed in the problem itself and participating in the solution proposals. This process digitalization is being developed in the company with the aim of contributing to the achievement of World Class Manufacturing status.

4. Results and Discussion
In order to achieve operational excellence, the company has a vision of having a team operating in a stable value stream that devotes more and more time to change, to become more efficient. Therefore, the company needs to strike a balance between stability, through the creation of standards (SDCA), and flexibility, through the ability to adapt to the ever-changing industrial world (PDCA). All this will be achieved through the elaboration of projects that allow constant improvements, and the sustainability of these improvements.
Figure 1 schematizes how these same projects are processed in the company under study. To better explain the scheme, let's imagine that a given project currently presents a problem generated by the occurrence of a process failure, being verified that the standard previously implemented is not being followed. A SDCA cycle is executed in order to take corrective actions to return to the standard, and after this standard is reached, it may be concluded that there are opportunities for improvement, being implemented a PDCA if the improvement is more significant, (e.g., implement

5S – lean tool - in a new production line), and an SDCA if the improvement is "smaller" (e.g., improve the 5S previously implemented in some line). In addition, and in the same line of thought, to solve the problem created by setting a new goal, never achieved before, a PDCA is performed.

Therefore, it can be said that PDCA and SDCA are used to sustain and give life to projects, being concerned with the current state, but also with what can be achieved further ahead.
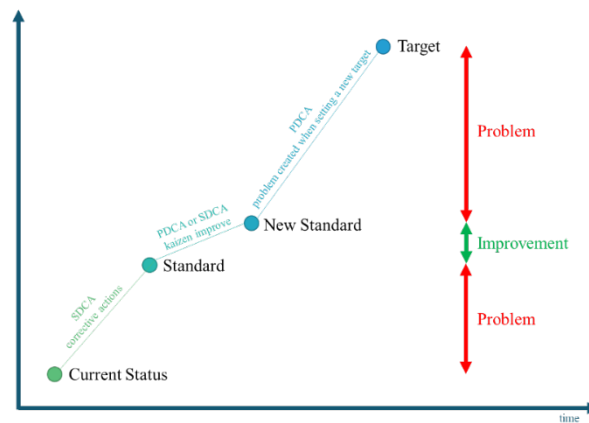

Figure 1. Problem Solving vs. Continuous Improvement (kaizen) (adapted from Hoshin Karin - Problems' Definition)

As seen previously, the digitalization process is now a necessity for the company, thus arising the question: "Which processes should be digitalized?"

To organize this path to digitalization, the company follows a well-defined methodology based on the lean thinking philosophy, PDCA and SDCA, according to the scheme presented in Figure 2, following the line of thought mentioned above.
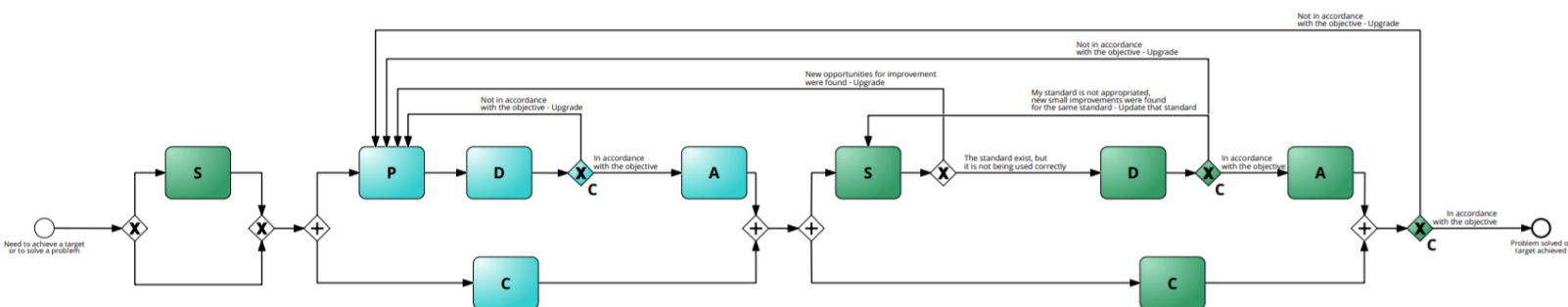

Figure 2. PDCA & SDCA explanation – the path for the digitization.

S □ First of all, it is essential to understand how the processes are developed at this point, since, according to Taiichi Onho, "Where there is no standard, there can be no kaizen" (improvements).

P □ Next comes the planning phase, where it is done: the task force responsible for the project; the survey of opportunities; the selection of processes to be digitized, according with the respective ICE (Impact, Cost and Easiness) indicator value; their specification; the budgeting, in order to understand the monetary need; and finally the implementation, where it is concluded according to the availability of CAPEX (capital expenditure) and human resources, which processes are priority to become digital. For this planning phase, a tool was developed based on support tool developed in excel, intitled DiYD (Do it Yourself Digitalization). The steps for its use are schematized in Figure 3.
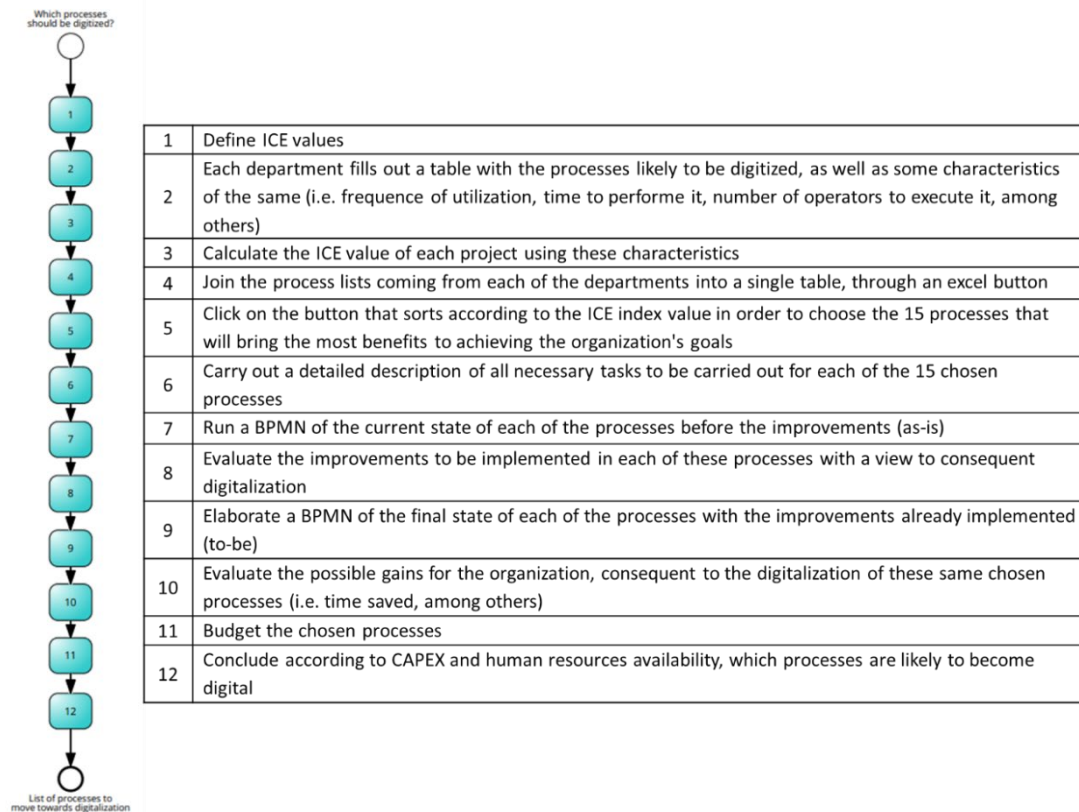
1	Define ICE values
2	Each department fills out a table with the processes likely to be digitized, as well as some characteristics of the same (i.e. frequence of utilization, time to perform it, number of operators to execute it, among others)
3	Calculate the ICE value of each project using these characteristics
4	Join the process lists coming from each of the departments into a single table, through an excel button
5	Click on the button that sorts according to the ICE index value in order to choose the 15 processes that will bring the most benefits to achieving the organization's goals
6	Carry out a detailed description of all necessary tasks to be carried out for each of the 15 chosen processes
7	Run a BPMN of the current state of each of the processes before the improvements (as-is)
8	Evaluate the improvements to be implemented in each of these processes with a view to consequent digitalization
9	Elaborate a BPMN of the final state of each of the processes with the improvements already implemented (to-be)
10	Evaluate the possible gains for the organization, consequent to the digitalization of these same chosen processes (i.e. time saved, among others)
11	Budget the chosen processes
12	Conclude according to CAPEX and human resources availability, which processes are likely to become digital

Figure 3. Explanation of the steps of "Which processes should be digitized?"

In the next figures, some screens of the tool can be seen: the Figure 4 presents the excel sheet where the steps 2 and 3 are done. In the same way, Figure 5 shows the sheet to do the steps 4 and 5. The AS-IS and TO-BE models are done in the excel sheets of the figures 6 and 8, respectively. The Figure 7 expose the excel to do the steps 6, 8, 10, 11 and 12. Also, in Figure 3, it can be find the steps that define the interaction between the user and the DiYD tool.

COMPANY   Department: EHS

	PROCESS		Existant solutions in the market	Tools used currently	Frequency of Realization	Week/ Month/Year	Freq/year	No. Collaborators Involved	No. Passages of Testimony	Average Duration Time (Days)	% Waste Estimated	Department	INDEX ICE			
ID	Name	Description											Impact	Cost	Easiness	ICE
1	proc1	Incident Management	t	kj	17	Week	884	3	3	6	10	EHS	7	8	1	56
2	proc2	Risk Analysis	y	u	3	Week	156	1	7	4	20	EHS	7	8	2	112
3	proc3	Documental Management	u	t	12	Year	12	18	10	7	30	EHS	7	8	2	112
4	proc4	Training Management	i	y	8	Month	96	10	20	8	5	EHS	10	8	4	320
5	proc5	Tasks	t	kj	5,5	Week	286	17,5	23,5	8,5	15	EHS	10	8	4	320
6	proc6	Environment Impact Evaluation	y	u	3,7	Month	44,4	21,3	28,9	9,4	14,5	EHS	10	8	4	320
7	proc7	Medical Apointments	u	t	1,9	Month	22,8	25,1	34,3	10,3	14	EHS	11	8	4	352
8	proc8	Wastes Management	i	y	2	Year	2	28,9	39,7	11,2	13,5	EHS	8	8	4	256
9	proc9	Ourtsourcing	t	kj	3	Year	3	32,7	45,1	12,1	13	EHS	8	8	4	256
10	proc10	Stocks Management	y	u	4	Month	48	36,5	50,5	13	12,5	EHS	11	8	4	352
11	proc11	Security Evaliation	u	t	8	Week	416	40,3	55,9	13,9	12	EHS	11	8	4	352
12	proc12	People Evaluation	i	y	5,5	Week	286	44,1	61,3	14,8	11,5	EHS	11	8	4	352
13	proc13	Teams Management	t	kj	3,7	Month	44,4	47,9	66,7	15,7	11	EHS	12	8	4	384
14	proc14	Quality Control Management	y	u	6	Year	6	51,7	72,1	16,6	10,5	EHS	10	8	4	320
15	proc15	People Complaints	u	t	3	Week	156	55,5	77,5	17,5	10	EHS	12	8	4	384
16	proc16	Verification Plan	i	y	2	Week	104	59,3	82,9	18,4	9,5	EHS	12	8	4	384

Figure 4. Step 2 and 3 of "Which processes should be digitized?"

Figure 5. Step 4 and 5 of "Which processes should be digitized?"

Figure 6. Step 7 of "Which processes should be digitized?"

Figure 7. Step 6, 8, 10, 11 and 12 of "Which processes should be digitized?"

Figure 8. Step 9 of "Which processes should be digitized?"

It is important to emphasize several aspects at this stage, one of them being the fact that each organization must understand what's the target with the digitalization, to understand which processes will bring the most benefits to the company with its digital transformation. This could be cost minimization, increased productivity, among others. In the practical case studied, the company aims to increase the efficiency of processes, thus increasing productivity and achieving the greatest amount of information.

Another aspect to highlight is the need to develop an AS-IS model and a TO-BE model for each process chosen, since it is important to apply improvements in them before moving on to digitalization itself. This is because this is one of the reasons why companies fail in the digital transformation and end up not benefiting from this transition and even harming themselves.

D ☐ After this phase is completed, it is time to perform the digitization of the processes or outsource this operation depending on their complexity and put them in a test phase with the operators that will perform these processes.

C ☐ The next step, called Check, focuses on verifying the achievement of objectives. Here a comparison is made of the values achieved with those we set as possible targets, using for example the Power BI platform. As a result of this phase, we can either start planning again if the targets have not been met or move on to the next phase.

A ☐ The next phase is Adjust, if the objectives have been achieved an operating standard is drawn up from which the way to perform these processes with embedded digitalization is stabilized (the lessons it is supposed to learn to perform these processes are listed). In addition, the operators that will perform the digitalized tasks are trained, to do the tasks in the best way.

SDCA ☐ To start the SDCA cycle, the standard from the adjust phase is analyzed and the question is asked: "Is the standard being followed? Do I have any opportunity to improve this standard?" From here two different and alternative situations may arise:
1. If the standard is not being followed a corrective action plan (with corrective actions) is executed and carried out in the next step – do -, and consequently the check step is made to verify that everything is going as planned. This may result in the need to make minor adjustments to the standard (back to the beginning of this cycle) or even to make major changes – new functionalities (back to the PDCA cycle);
2. If improvements that can be implemented are found, a new PDCA cycle is started to make these upgrades to the standard. The organization under analysis follows the idea that the SDCA is a method used both for stabilizing a process before further improvements are applied, and also for maintaining a new standard after improvements have been implemented.

According to the ideas described in the literature review, this methodology explained above (in the figure 2) can be considered a roadmap for digital transformation, since it addresses the themes of the phases demonstrated in (Issa et al. 2018), and fills the gap of most models, stated by (Bellantuono et al. 2021), since the phases of implementation and consolidation of this digital transformation are discussed in the methodology adopted by the portuguese company under analysis.
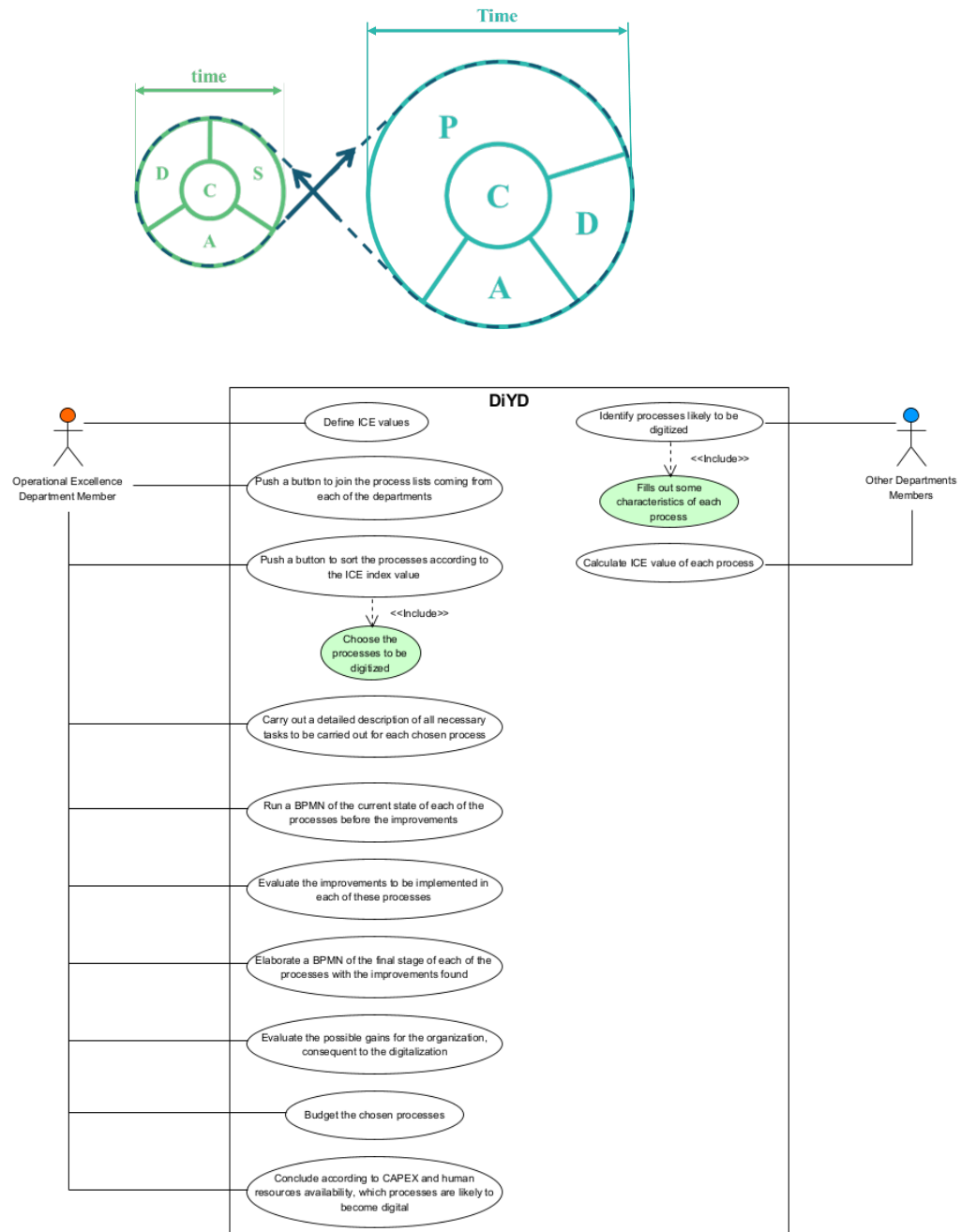
Figure 10. PDCA & SDCA framework

As can be seen in the BPMN of figure 2, the check is a phase that happens continuously and in parallel with all the others, since it is necessary to constantly check if what is being done meets the goal, contributing this way to the continuous monitorization of the results. Thus, and based on this idea, this cycle can be represented and schematized as in figure 10, so that it is possible to adapt the route to be followed. In the same figure it is possible to see that the diameter of the SDCA circle (time) is smaller than the diameter of the PDCA circle (Time), because to implement the PDCA cycle it takes significantly more time than to implement the SDCA. This framework is used in the company as the basis for sustaining any of the projects, seeking to manifest the concern not only with what is intended to be achieved through improvements and problem solving (future state), but also with the current state of the situation.

As it was stated before, it is well known in the literature that PDCA & SDCA methodologies apply the principle of continuous improvement to solve problems or even implement new solutions, thus becoming essential tools for effective change management. Therefore, the framework presented in figure 10 was developed to align these two methodologies in order to achieve change (PDCA) and stabilize and maintain (SDCA) its results, being this second one (consolidation of the change) a common limitation of the roadmaps stated in the literature. In this way, since the digitalization of processes is nothing more than the adaptation of processes to the digital paradigm, the framework turns out to be a good ally to successfully achieve the objectives. Moreover, it is stated in the literature that one of the essential steps of this transformation concerns the selection of priority projects to advance, which, depending on the company in question may be based on several criteria, such as: payback period, economic efficiency, project risks, among others (Shaykhulova and Selivanov 2021). The tool using excel from Microsoft was presented in order to contribute to the success of this step, which can be adopted by several companies, regardless of the industry in which they operate.

Analyzing the six phases described by (Issa et al. 2018) and comparing it with the methodology presented in this article (PDCA & SDCA in the digital transformation process), this can also be considered a roadmap for digitization, since it follows the steps mentioned in section 2.4 of the literature review, from the definition of the team to act (task force setup), to the selection of processes to be digitized, using the tool developed in excel to the other five phases.

As mentioned before in the literature review by Issa (Issa et al. 2018), each roadmap is unique to each company, and this methodology can be used as the basis for developing a roadmap for the digital transformation of any company and should be adjusted to the concept and background of that organization.

With this, it is possible to see that it is essential to preserve what is already taken as a basis in the company, WCM (integrating lean tools and philosophies), with what are the objectives for the future, digital transformation. In conclusion, the methodology explained above (PDCA & SDCA in the digital transformation process) presents itself as a way for lean to support the integration of Industry 4.0 in the industrial environment, filling that way the gap stated in (Salvadorinho and Teixeira 2021b).

5. Final remarks and future work
This study shows how process modelling can support the implementation of World Class Manufacturing (WCM) tools (with Lean Management integrated), considering the digital paradigm. The roadmap defined using lean tools, such as PDCA and SDCA is proposed to achieve digitalization of processes, which can be considered a theme that fills the gap in the literature that Lean can support the integration of Industry 4.0 in the industrial environment.

Furthermore, presented a support tool developed in Excel to assist in the application of the proposed methodology, using the BPMN tool as its basis. Thus, it was possible to conclude that this methodology (PDCA & SDCA in the digital transformation process) can be considered a roadmap for digital transformation, which fulfills the steps found in the literature, filling the gap that exists in that most roadmaps do not consider the phases of implementation and consolidation of results.

This roadmap can be considered a set of best practices to be followed by organizations to accomplish digital transformation. This way it allows companies to adopt Industry 4.0 technologies in a structured way, preserving what the company already follows, the lean philosophy. Moreover, and as mentioned before, companies should adjust these steps to their own reality, since each roadmap concerns a company, being necessary to adapt it according to its background.

After the analysis of the whole case study, it is important to mention that as in all projects, it is possible to find opportunities for improvements. Therefore, as a suggestion for future work, it would make sense to also digitize this process that uses the Excel tool. This way it would avoid errors and make the process more intuitive, so that the process is more productive and has a more robust conclusion about the processes to be digitized. That said, it has been found that this can be done, applying digitalization, with the development of an application in Microsoft's Power Apps tool.

To sum up, it is crucial that organization invest in organizing the planning of the digital transformation process, and Lean tools can be used for this, preserving what already exists in the organization's environment.

References

Arevalo, C., Escalona, M. J., Ramos, I., & Domínguez-Muñoz, M. (2016). A metamodel to integrate business processes time perspective in BPMN 2.0. Information and Software Technology, 77, 17–33. https://doi.org/10.1016/j.infsof.2016.05.004

Bellantuono, N., Nuzzi, A., Pontrandolfo, P., & Scozzi, B. (2021). Digital transformation models for the i4.0 transition: Lessons from the change management literature. Sustainability (Switzerland), 13(23). https://doi.org/10.3390/su132312941

Bittencourt, V. L., Alves, A. C., & Leão, C. P. (2019). Lean Thinking contributions for Industry 4.0: A systematic literature review. IFAC-PapersOnLine, 52(13), 904–909. https://doi.org/10.1016/j.ifacol.2019.11.310

Castro, S., & Teixeira, L. (2020). Bpmn and lean contributions for the iso9001 implementation: A case study within the plastics industry. Proceedings of the International Conference on Industrial Engineering and Operations Management, August, 1228–1237.

Chinosi, M., & Trombetta, A. (2012). BPMN: An introduction to the standard. Computer Standards and Interfaces, 34(1), 124–134. https://doi.org/10.1016/j.csi.2011.06.002

Cifone, F. D., Hoberg, K., Holweg, M., & Staudacher, A. P. (2021). 'Lean 4.0': How can digital technologies support lean practices? International Journal of Production Economics, 241(August), 108258. https://doi.org/10.1016/j.ijpe.2021.108258

D'Orazio, L., Messina, R., & Schiraldi, M. M. (2020). Industry 4.0 and world class manufacturing integration: 100 technologies for a WCM-I4.0 matrix. Applied Sciences (Switzerland), 10(14). https://doi.org/10.3390/app10144942

Dombrowski, U., Richter, T., & Krenkel, P. (2017). Interdependencies of Industrie 4.0 & Lean Production Systems: A Use Cases Analysis. Procedia Manufacturing, 11(June), 1061–1068. https://doi.org/10.1016/j.promfg.2017.07.217

Ebrahimi, M., Baboli, A., & Rother, E. (2019). The evolution of world class manufacturing toward Industry 4.0: A case study in the automotive industry. IFAC-PapersOnLine, 52(10), 188–194. https://doi.org/10.1016/j.ifacol.2019.10.021

Gökalp, E., & Martinez, V. (2021). Digital transformation capability maturity model enabling the assessment of industrial manufacturers. Computers in Industry, 132. https://doi.org/10.1016/j.compind.2021.103522

Gomes, S. B., Santoro, F. M., & Da Silva, M. M. (2020). An ontology for BPM in digital transformation and innovation. International Journal of Information System Modeling and Design, 11(2), 52–77. https://doi.org/10.4018/IJISMD.2020040103

Hughes, L., Dwivedi, Y. K., Rana, N. P., Williams, M. D., & Raghavan, V. (2022). Perspectives on the future of manufacturing within the Industry 4.0 era. Production Planning and Control, 33(2–3), 138–158. https://doi.org/10.1080/09537287.2020.1810762

Issa, A., Hatiboglu, B., Bildstein, A., & Bauernhansl, T. (2018). Industrie 4.0 roadmap: Framework for digital transformation based on the concepts of capability maturity and alignment. Procedia CIRP, 72, 973–978. https://doi.org/10.1016/j.procir.2018.03.151

Jagusiak-Kocik, M. (2017). PDCA cycle as a part of continuous improvement in the production company - A case study. Production Engineering Archives, 14(14), 19–22. https://doi.org/10.30657/pea.2017.14.05

Kadir, B. A., Broberg, O., Souza da Conceição, C., & Jensen, N. G. (2019). A framework for designing work systems in industry 4.0. Proceedings of the International Conference on Engineering Design, ICED, 2019-Augus(AUGUST), 2031–2040. https://doi.org/10.1017/dsi.2019.209

Kagermann, H. (2015). Change Through Digitization—Value Creation in the Age of Industry 4.0. In Management of Permanent Change (pp. 23–45). https://doi.org/10.1007/978-3-658-05014-6

Kolberg, D., Zühlke, D., Kolberg, D., & Kolberg, D. (2015). Lean Automation enabled by Industry 4.0 Technologies. https://doi.org/10.1016/j.ifacol.2015.06.359

Lederer, M. (2019). What's going to happen to business process management? Current status and future of a discipline. CEUR Workshop Proceedings, 2388.

Łyp-Wrońska, K. (2016). World Class Manufacturing methodology as an example of problems solution in Quality Management System. https://doi.org/https://doi.org/10.4028/www.scientific.net/KEM.682.342

Maimone, F. (2022). Organizing for Industry 4.0. In Do machines dream of eletric workers? (Vol. 49, pp. 1–20). https://doi.org/10.1007/978-3-030-83321-3_1

Marsikova, K., & Sirova, E. (2018). Optimization of selected processes in a company with the support of the lean concept. MM Science Journal, 2018(March), 2300–2305. https://doi.org/10.17973/MMSJ.2018_03_2017111

Mayr, A., Weigelt, M., Kühl, A., Grimm, S., Erll, A., Potzel, M., & Franke, J. (2018). Lean 4.0-A conceptual conjunction of lean management and Industry 4.0. Procedia CIRP, 72, 622–628.

  https://doi.org/10.1016/j.procir.2018.03.292

Mehdouani, K., Missaoui, N., & Ghannouchi, S. A. (2019). An approach for Business Process Improvement Based on Simulation Technique. Procedia Computer Science, 164, 225–232. https://doi.org/10.1016/j.procs.2019.12.176

Novická, A., Papcun, P., & Zolotová, I. (2016). Mapping of machine faults using tools of World Class Manufacturing. SAMI 2016 - IEEE 14th International Symposium on Applied Machine Intelligence and Informatics - Proceedings, 223–227. https://doi.org/10.1109/SAMI.2016.7423011

Retamozo-Falcon, G., Silva, J., & Mauricio, D. (2019). Model for the improvement of processes using Lean techniques and BPM in SMEs. Proceedings of the 2019 IEEE 26th International Conference on Electronics, Electrical Engineering and Computing, INTERCON 2019, 2019–2022. https://doi.org/10.1109/INTERCON.2019.8853806

Salvadorinho, J., & Teixeira, L. (2020). The bilateral effects between industry 4.0 and lean: Proposal of a framework based on literature review. Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management, August, 643–654.

Salvadorinho, J., & Teixeira, L. (2021a). Organizational knowledge in the I4.0 using BPMN: A case study. Procedia Computer Science, 181(2019), 981–988. https://doi.org/10.1016/j.procs.2021.01.266

Salvadorinho, J., & Teixeira, L. (2021b). Stories Told by Publications about the Relationship between Industry 4.0 and Lean: Systematic Literature Review and Future Research Agenda. Publications, 9(3), 29.

Shaykhulova, A. F., & Selivanov, S. G. (2021). Digital transformation strategy development for industry 4.0. AIP Conference Proceedings, 2402(November), 0–4. https://doi.org/10.1063/5.0071311

Tripathi, V., Chattopadhyaya, S., Mukhopadhyay, A. K., Sharma, S., Li, C., & Di Bona, G. (2022). A Sustainable Methodology Using Lean and Smart Manufacturing for the Cleaner Production of Shop Floor Management in Industry 4.0. Mathematics, 10(3), 347. https://doi.org/10.3390/math10030347

Turconi, G., Ventola, G., González-Prida, V., Parra, C., & Crespo, A. (2022). A Literature Review on Lean Manufacturing in the Industry 4.0: From Integrated Systems to IoT and Smart Factories. In IoT and Cloud Computing for Societal Good (pp. 181–194). https://doi.org/10.1007/978-3-030-73885-3_11

Zaoui, F., & Souissi, N. (2020). Roadmap for digital transformation: A literature review. Procedia Computer Science, 175, 621–628. https://doi.org/10.1016/j.procs.2020.07.090

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Juliana Salvadorinho completed a MSc. degree in Industrial Engineering and Management in 2020 from University of Aveiro. She is currently pursuing a PhD in Industrial Engineering and Management (also from University of Aveiro) acting as a researcher for the Foundation for Science and Technology (FCT). She also collaborates in the Augmented Humanity Project funded by the National Agency for Innovation. She has published several scientific articles in international conferences and journals and has received 17 awards recognize her academic path. Her focus is on Engineering Sciences and Technologies, with emphasis on the following terms of contextualization of scientific and technological production: Industry 4.0; Lean Manufacturing; Business Process Management; BPMN; Information Systems; Manufacturing Execution System; Data Visualization; Human Factor; Knowledge Management.

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Leonor Teixeira graduated in Industrial Engineering and Management, received a MSc. degree in Information Management, and a PhD in Industrial Management (Information Systems area), in 2008, from the University of Aveiro, Portugal. She is currently an Associate Professor of the Department of Economics, Management, Industrial Engineering and Tourism (DEGEIT) at the University of Aveiro. She is also a researcher (Integrated Member) at the Institute of Electronics and Informatics Engineering (IEETA) / Intelligent Systems Associate Laboratory (LASI) and collaborator at research unit on Competitiveness, Governance and Public Policies (GOVCOPP) of University of Aveiro. Her current research interests include Industrial Management in general, and in Information Systems applied to Industry in particular. She has over 200 publications in peer-reviewed journals, book chapters and proceedings, and has several communications at international scientific conferences, some of which as invited speaker. She serves as a member of Program Board and Organizing Committees for several Scientific Committees of International Conferences and has collaborated as reviewer with several journals. She is associated with IIIS and APSI/PTAIS.