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Data Science and Advanced Analytics

Maturity model to position and orient organizations through the process automation implementation

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Dissertation

presented as partial requirement for obtaining the Master Degree Program in Data Science and Advanced Analytics

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Maturity Model to position and orient organizations through the Process Automation implementation

by

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Dissertation presented as partial requirement for obtaining the Master's degree in Advanced Analytics, with a Specialization in Business Analytics

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September 2022

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledge the Rules of Conduct and Code of Honor from the NOVA Information Management School.

Beatriz Chumbinho

Lisbon, September 2022

ABSTRACT

Nowadays, companies are seeking for processes done with a zero error rate enhancing their service quality, while the demand for costs reduction and speed is also increasing. For these reasons, the value of Artificial Intelligence is raising, namely in the area of optimization and processes automation. These concepts lead to a hot topic: Hyperautomation, which aims to achieve an environment where machines are working together with each other or alongside human employees. However, it is not clear what does the introduction of intelligence means in processes. Previous studies have defined maturity models regarding Business Process Management or Industry 4.0, but there is a gap in this topic for the automation area.

The Design Science Research Methodology (DSRM) was applied to build a Maturity Model that can help position and orient organizations through the process automation implementation. The model aims to be a framework where the companies can rely to be successful in the journey of automating and optimizing business processes not only by understanding their position but also finding the actions needed to improve. Thus, the Maturity Model incorporates a taxonomy to classify each level as well as a description of what each level represents. Additionally, the proposed Maturity Model provides an evaluation framework.

KEYWORDS

Maturity Models; Artificial Intelligence; Processes Automation; Hyperautomation

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LIST OF ABBREVIATIONS AND ACRONYMS

APQC PCF American Productivity & Quality Center Process Classification Framework

AI Artificial Intelligence

AR Augmented Reality

BI Business Intelligence

BPA Business Process Automation

BPM Business Process Management

BPMM Business Process Maturity Model

BPMMM Business Process Management Maturity Model

BPMM-OMG Business Process Maturity Model from Object Management Group

BPMS Business Process Management System

BPRMM Business Process Reengineering Maturity Model

CMMI Capability Maturity Model Integration

CMMI-ACQ CMMI for acquisition

CMMI-SVC CMMI for services

CPS Cyber-Physical Systems

DL Deep Learning

DSRM Design Science Research Methodology

DMS Document management systems

EDMS Electronic Document Management System

GUI Graphical User Interface

IR Industrial Revolution

IS Information Systems

IT Information Technology

IPA Intelligent Process Automation

IoT Internet of Things

KNN K Nearest Neighbors

KRI Key Risk Indicators

PEMM Process and Enterprise Maturity Model

PCM Process Condition Model

PMMA Process Management Maturity Assessment

PML Process Maturity Ladder

PM Process Mining

RFID Radio Frequency Identification

ROI Return on Investment

RPA Robotic Process Automation

SAM Strategic Alignment Maturity Model

SEI Software Engineering Institute

SMEs Small and Medium Enterprises

VR Virtual Reality

WfMS Workflow Management System

YoY year over year

INTRODUCTION

The present section aims to introduce and open the theme proposed in this dissertation: A Maturity Model to position and orient organizations through the Process Automation implementation. This way, a general context of the subject in scope will be presented as well as the motivation for choosing it. Additionally, the proposed objectives and the relevance of the subject under study will be exposed in this section as well.

1.1. CONTEXT

High data volumes of different structures flow within organizations everyday which traditionally would lead to an increasing of errors, slowness, and incoordination. However, the world is walking into a sophisticated level of requirement where companies are seeking for processes done with a zero-error rate enhancing their service quality, while the demand for costs reduction and speed is also increasing (Anagnoste, 2017). For these reasons, the value of Artificial Intelligence (AI) is raising, namely in the area of optimization and processes automation (Kedziora & Kiviranta, 2018). Together with Business Process Automation (BPA) which is a field of Business Process Management (BPM), Robotic Process Automation (RPA) has become an essential tool in process optimization for many organizations within different industries (Mühlberger et al., 2020). When adopting RPA, companies have the opportunity of moving their employees from redundant to high value-added activities, both in back and front office (Anagnoste, 2017). Despite the multiple benefits of RPA, it has a significant limitation as it is prepared to be applied only in labour-intensive and monotonous tasks with simple and well-defined rules. This means that software is not prepared to judge, i.e., to be intelligent (Huang & Vasarhelyi, 2019). Farther, RPA machines can interact with information systems (IS) through graphical user interfaces (GUI), but lacks in the ability of integrating processes with each other (Siderska, 2020).

Hereupon, automate processes through RPA and use BPM methodologies to optimize them is good but the trend is already ahead. There is the need of add intelligence to this game in order to let the robots execute more complex tasks moving from RPA to Intelligent Process Automation (IPA) (Mühlberger et al., 2020). Here, the AI role is to assign cognitive capabilities to the machines and raises the sophistication bar when robots reach a baseline where they can mimic human behaviour and thus make decisions (Ng et al., 2021). Furthermore, there are authors who propose an approach to achieve end-to-end automation of RPA suitable processes. This proposal suggests generating RPA scripts from logs, in order to perform the activities in question (Mühlberger et al., 2020). Having these facts into account, it becomes possible to understand that automation, intelligence, and integration are inevitable, and that the world is moving directly towards Hyperautomation.

Hyperautomation marries RPA with AI and increases its potential when allied with BPM methodologies to connect the different IPAs within the organization, enabling end-to-end automated processes (Mühlberger et al., 2020). As previously mentioned, RPA stands for automating isolated processes, while, as the name itself suggests, hyperautomation offers automation while performs a minute coordination between the IPAs, responding to the orchestration of the company's process architecture. According to Gartner, hyperautomation is in the first position of the top 10 strategic technology trends which it is expected to drive into a substantial disruption on the working world this decade. Additionally, the expected year over year (YoY) application integration's growth would be about 40% in 2022 (Lasso-Rodriguez & Winkler, 2020b).

Despite being consensual that hyperautomation can provide widespread benefits for organizations, it is not clear what does the introduction of intelligence means in processes (Mühlberger et al., 2020). This implies that companies are not able to self-assess their degree of maturity and perceive what can they do to improve and move to the next level.

1.2. Motivation

Maturity Models (MM) are a technique to position companies in their progress and enable the measurement in several aspects of business processes (Proença & Borbinha, 2016). The creation of this tool starts from the premise that things change, and everything flows more adequately when organizations know where they are and in which direction they want to go (Kawamura & Schultz, 2005). MM intends to approach the processes life cycle from a goals-oriented perspective. The purpose of MM is to provide a path to the next level of optimization, defining different levels, from the initial stage to the state-of-the-art, as well as the necessary steps to fill the gaps between the current and the desired level (Proença & Borbinha, 2016).

Therefore, MM can be considered as models, in the sense that they provide an explanatory description of each stage of the maturity line, and they can also be interpreted as methodologies, since they allow a systematic and goal-oriented move to reach the desired solution (Mettler & Rohner, 2009). The benefits of adopting MM within an enterprise are based on the MM purposes, which include granting an *AS IS* assessment of the organization's strengths and weaknesses, as well as being able to serve as a guide for improving optimization and benchmarking, and a comparison or positioning tool (Roquete, 2018).

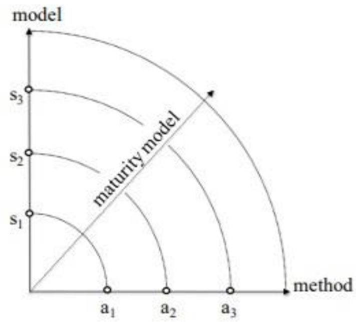

Fig. 1 – MM between models and methods
(Mettler & Rohner, 2009)

Previous studies have defined MM in the technological area, namely regarding Industry 4.0 (Santos & Martinho, 2020) and even in the process optimization field, as it is the case of BPM (Roquete, 2018).

However, in the area of processes automation, there is a gap regarding MM and there is a handicap in finding documentation related to this specific topic. Consequently, when going through the process optimization journey, enterprises nowadays do not have a guide on the automation component. This way, they can position and measure themselves only regarding the optimization of processes, using BPM, and as previously demonstrated in this document, the automation part is an indispensable element for success. Therefore, an important topic to be explored would be the proposal of a taxonomy and a process for classifying business processes automation.

The ambition of this paper is to define different maturity stages to classify enterprises in the processes automation journey and help them to improve their level of automation.

1.3. Objectives

Having into consideration the gap identified, the research question is: How to assess and position companies' maturity in process automation?

In order to answer the research question, the research goal would be to:

- Incorporate a taxonomy/ maturity level for the classification of business processes automation, based not only on the level of automation within the organization but also considering the level of processes intelligence.
- Define a guideline describing the needed steps to move for the next automation level.
- Provide a framework to support the model, so that an organization can be effectively evaluated on its automation journey

1.4. Study Relevance and Importance

The presence of robots in the society everyday life, namely in organization's quotidian, is undeniable and the trend is increasing (Mühlberger et al., 2020). Also, accordingly to Gartner, hyperautomation takes the first position of the top 10 strategic technology trends which will change the way people work, as well as the functions performed and, consequently, the life in society (lasso-rodriguez & winkler, 2020b).

As already mentioned in the *context* section of the present study, the benefits of automation for the economy are varied and easily identifiable: work performed with more accuracy, less errors and in a faster rhythm and a lower monetary charge is associated with the processes (Anagnoste, 2017). This is, in a more efficient mode. Additionally, the introduction of automation, namely the intelligent one, boosts competitiveness between companies (Vishnoi et al., 2019) which is a benefit for the end users.

The future of human employment is often speculated as robots are able to replace some functions hitherto performed by people. This can be considered one of the challenges of this era: how to relocate people in the labour market? If the issue is looked at realistically, robots do not just take work away from humans. On the contrary, with the use of robots other functions appear to be performed by people (Syed et al., 2020), not only in the creative and emotional aspect but also in the aspect of working for the proper functioning of the robots themselves.

However, there is the need of planning and understand the positioning of a certain organization when approaching themes of this nature. For that reason, there are MM applied to Industry 4.0 (Santos & Martinho, 2020) or BPM (Roquete, 2018). Regarding the management and optimization of business processes, following a MM helps to boost the company, namely in process results. There are authors, such as Renata Gabryelczyk, who argue that the use of a MM can express the ability of a company to improve (Gabryelczyk, 2018).

However, to be able to plan and find out what is needed, it is necessary to plan the automation itself.

2. LITERATURE REVIEW

The purpose of this section – Literature Review – is based on the research about topics closely related to the study covered in this paper. Subsequently, the knowledge obtained through this literature review will be a participant object in the proposal that will be the result of this dissertation.

2.1. PROCESS AUTOMATION

To properly contextualize the theme of the present dissertation, it is important to start by expose what process automation is. Thus, it is possible to say that process automation is the automation of processes through the use of computers and software, in order to need less human interaction, which helps in a matter of efficiency (IT BusinessEdge, 2016).

The process automation subject can direct us to concepts as Workflow automation, RPA, IPA and hyperautomation, being them different tools for process optimization and/ or automation, with different degrees of integration and intelligence. Generically, it can be said that workflow automation represents a subject of workflow management systems which aims to turn the organization more efficient, namely by integrating heterogeneous application systems (Stohr & Zhao, 2001). Regarding RPA, it can be defined as a software based on simple and well-defined business rules to automate isolated processes with the need of human intervention to handle exceptions (Hofmann et al., 2020). The IPA can be seen as the RPA successor, since it automates processes while adding machine learning and artificial intelligent capabilities to the software. This way it can mimic the human behaviour and learn with the past experience (Berruti & Taglioni, 2017). Finally, hyperautomation, as already mentioned, combines IPA with a massive integration within the workforce environment (Berruti & Taglioni, 2017).

Those concepts will be better explained in a further stage of the present section.

2.2. CONCEPTS

In the following paragraphs it is possible to find a contextualization of the core concepts of Process Automation, which includes processes, business process management and automation.

2.2.1.1. Processes

Taking into account what does this concept means in the technology field, a process is composed by workflows with well-defined entries and exits, with sequentially dependent steps (Sangadah, 2020). The workflows are a set of activities, with defined rules, that are performed by an actor who can be a human or a machine (Paim & Magalhaes, 2009). This way, a process can be seen as a method or set of steps that should be followed, in order to reach a certain outcome (Sangadah, 2020).

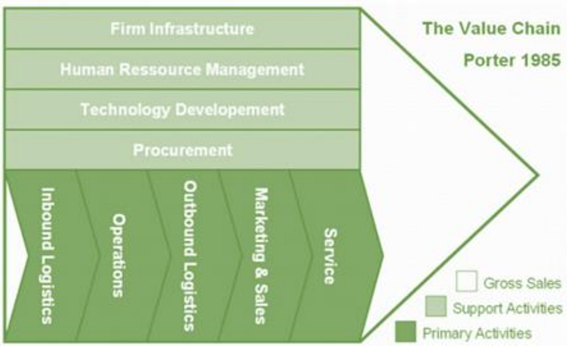

Fig. 2 – Porter's value chain model – 1985 (Dumas et al., 2013)

In a matter of business processes, different authors defend different perspectives, since some of them group the business processes into two main clusters and others defend a segmentation of three or even more (Dumas et al., 2013). A famous author is Porter, who defended three different process groups: primary activities (e.g., logistics), support activities (e.g., procurement and sales themselves).

However, more recent models have been developed and the one known as "After Porter's Value Chain" considers the stakeholders (customers and suppliers) (Dumas et al., 2013) and its architecture can be observed in Fig. 4.

However, there are authors, as Geary Rummler, who defend a simpler approach, which in fact can purely translate the objective of having processes. This way, one can group processes into three core processes: sell, deliver, and make sure you have things to sell and deliver (Dumas et al., 2013).

In a nutshell, a business process can be defined as a sequence of activities whose the final aim is to provide value for the organization and consequently for the customer (Sangadah, 2020).

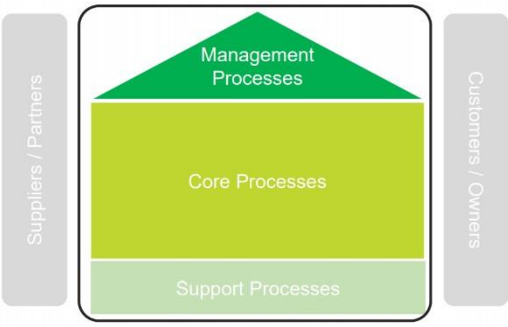

Fig. 3 – After Porter's value chain model – 1985 (Dumas et al., 2013)

2.2.1.2. BPM (Business Process Management)

It is unrealistic and dangerous to believe that it is possible to have a deep knowledge on processes just trusting on the routine. Without a thorough process specification, it is hard to find inefficiencies and thus improve the organization´s performance (Sangadah, 2020).

Here, emerges Business Process Management (BPM), a subject that is responsible for establishing a set of methodologies and tools able to combine knowledge from several areas, with the purpose of improving business processes (Aalst et al., 2016). This way, BPM goal is to support a feasible and efficient business process management as the name itself implies (Roquete, 2018).

Therefore, BPM should not be treated as a software, but as a core constituent for the proper functioning of organizations (Roquete, 2018), since it includes not only methodologies, tools and organizational structures, but also provides a culture within the organization, with well-defined roles and policies. This way, BPM assumes a continuous "as is" analysis, followed by a "to be" design, implementation, and monitoring, in order to enable an end-to-end optimization (Pinto & Santos, 2020).

BPM is the result of an evolution of process management over time, with its first records relating to the date of the industrial revolution where people understood that professionals are more successful when specializing their tasks (Pinto & Santos, 2020). More recently, three different strands of process management have emerged. The first one, process improvement, is centred in quality and task efficiency and was boosted through the use of technology in the business environment. The second one, process reengineering, aimed to change the structures and flows of processes and is characterized by a radical and one-step change with long implementation times.

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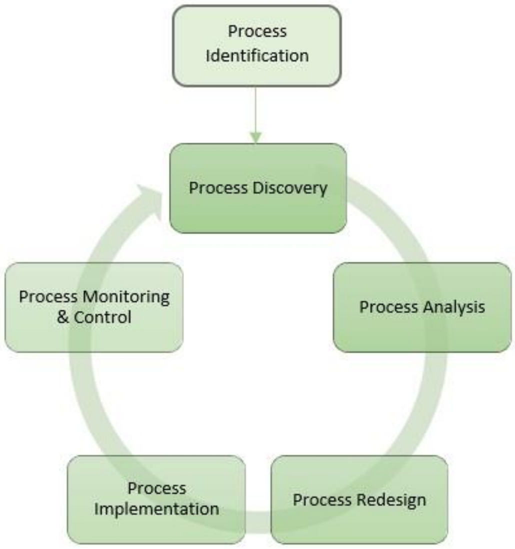

Fig. 4 – BPM Life-Cycle (Dumas, et al., 2013)

2.2.1.3. Automation

Automation comes from the Greek word "autómatos", which would be translated as "acting by itself". The concept of automation can be defined through the idea of operating independently of human interaction and has on its basis the use of machines, tools and systems.

As it is possible to presume, the first appearances of automation were purely mechanical and changed the way humans work through the processes' optimization. An excellent example are the windmills positioned in the 17th century. Later, on 18th century, James Watt created the flyball governor with the goal of replace human control of steam engine speed. It was in the 19th century that telecommunications were optimized using electricity and thus giving rise to the telegraph. As expected, automation has evolved to the present day, in which several tasks of our daily lives are optimized by automation.

In the last decade, the Robotic Process Automation (RPA) tool has been increasing its importance in the organization's environment and increasing its potential when combined with a good BPM strategy. This way, robots started to perform simple business processes until then processed by human employees (Lester, 2007). As already mentioned in the present document, RPA is making room for an even more sophisticated form of automation that introduces intelligence and judgment (Lester, 2007) known as Intelligent Process Automation (IPA).

Fig. 5 – Evolution of Automation

2.2.2. Areas

Automation is seductive for all branches of activity: from industry to financial activity or human resources, as can be seen in the following paragraphs. Below, some important areas are discussed.

<u>INDUSTRY</u>

As the name itself demonstrates the Industrial Revolution (IR) was the great engine for the automation of the second sector of activity, the industrial one, which includes factories. This revolution has completely changed the way humans live and perform their work. It was one of the few moments in our history with these characteristics, joining the Neolithic Revolution where humans began to have agriculture as the main activity instead of hunting every day (Stearns, 2018). The evidence between the genesis of IR and the automation sought today is clear: replacing human (and animal work at IR) by automation, through new sources of power, making processes faster and with a better quality. IR contributed to a better organization of Human Resources and consequently to its specialization of tasks. Before IR, the power of work was mainly human and animal based so this revolution has introduced motors moved by fossil fuels and steam (Stearns, 2018). Automation of industry is not, therefore, something new in the mind of the human species since this revolution belongs to the XVIII and XIX centuries.

As expected, the needs of the industry are currently at a higher level, as it is necessary not only to increase quality and decrease processing times, but also to be more responsive to global market changes and closer to consumers. Additionally, the main goals for factories, declared by European Commission, include manufacturing the products of the future while the social and environmental balance is guaranteed (Dotoli et al., 2019).

There are numerous potential target processes for optimization and automation in industry and this theme leads to industry 4.0. To start with, the production cycle must be fully connected from the planning to the deployment phase and for that there is the need to include data integration in the agenda. Optimizing the resources involved in the process and the tasks themselves is also crucial in order to take the production closer to the limit, while maintaining the solidity of the process and increasing resources efficiency.

The autonomy of machines and communication integration between human employees, machines and systems are also in the automation queue. In a matter of analysing high volumes of facts generated every minute, the big data subject is inevitable, since it can support many processes related with predictions of, e.g., sales, segmentation of, e.g., products or customers, among others. The human-robot interaction is also a hot topic for the industry nowadays, since it is necessary to not only use both human and technological workforce but also to coordinate them, give them the respective and appropriate activities and make them aware of each other's state of tasks (Dotoli et al., 2019).

Linked to these needs, the Internet of Things (IoT) has emerged. IoT is characterized by the optimization of processes and systems, connecting agents – whether people, machines, programs – among themselves, in order to enable communication between the agents which allows an automation increment (IRENA, 2019). RPA allied with AI has boosted the industry 4.0 evolution, namely regarding information extraction, forecasting, process optimization or classification problems. Algorithms of Artificial Neural Networks and techniques of Text Mining and Natural Language Processing or computer vision have been raising the operation of companies/ industry.

The introduction of automation allows the reduction of costs and the quality improvement of complex tasks developed by machines, i.e., the final product will have a higher quality at a more attractive price. The manufacturing is thus facilitated, and this is the core of industry 4.0, this is its objective (Ribeiro et al., 2021). It should be noted that this concept is closely linked with Cyber-Physical Systems (CPS). These systems can be characterized by the integration and collaboration between computer technology, control, and communication, enabling a real-time and secure collaboration (Liu et al., 2017).

Although the world is currently experiencing industry 4.0, industry 5.0 may be approaching, which, with the help of AI, focuses on placing the human being at the centre of the society, solving the industry 4.0 problem. 5.0 industry can be characterized by the usage of advanced technologies and automation to increase the quality of our life, i.e., in health, in industry, among others (Skobelev & Borovik, 2017) through a synergy between humans and autonomous machines (Nahavandi, 2019).

The motivation of the Fifth Industrial Revolution is to bring humans and machines together, in order to enhance the use of the human brain as well as the creativity inherent to it, enabling to increase the efficiency of the processes. The goal is to achieve an environment where machines are able to understand the human desire and humans will, comfortably, work alongside robots. The advance of technology is crucial to achieve this objective, namely in fields as deep learning and intelligent autonomous systems. Industry 5.0 can revolutionize manufacturing, as it combines the benefits of industry 4.0 with the integration of the human being. Additionally, it is expected the creation of jobs not only related to emotional or creative capacities of our specie but also to technical needs to, e.g., maintain, program, train or schedule the robots (Nahavandi, 2019).

This way, within the scope of the APQC PCF (American Productivity & Quality Center Process Classification Framework), the category "Develop and Manage Products and Services" has several process groups than can be a target for automation implementation, as it is exampling the "Govern and manage product/ service development program" or the "Develop products and services". Within the process group of "Manage Customer Service", one can affirm that the "Plan and manage customer service contacts" process can be facilitated with the introduction of, e.g., predictive models, as well as "Evaluate customer service operations and customer satisfaction" can be favoured with the use of automation, for e.g., read and process the data. Regarding the "Manage Information Technology (IT)" group, one can point the "Develop and manage IT customer relationships", "Develop and manage IT business strategy" and "Manage information" processes to be object of automation and optimization capabilities.

FINANCE

Over the last years, RPA has emerged as an influential mean to increase decision making effectiveness in the financial sector due to the automation of tasks. RPA has been improving the productivity and consequently has raised the Return on Investment (ROI). As is many other business areas, the purpose of RPA usage in corporate finance is to decrease processing times while reducing costs and also allowing the release of tasks that don't require a lot of mental effort from employees, letting them focus on activities with the need of valuable human skills, e.g., as customer interaction. Thus, corporate finance has been adopting RPA for tasks as billing, accounts receivable, fixed asset accounting and many other back-office processes. Additionally, RPA can help companies understanding which activities are good candidates for outsourcing, usually routines ones, and which are not core tasks (*View of Robotic Process Automation and Effectiveness of Financial Decisions_ A Critical Review.Pdf*, n.d.).

Besides RPA, corporate finance is also seeking for intelligence (IPA), in order to allow the machines to, e.g., predict investor's behaviour, better evaluate situations where it is beneficial to accept or not accept credit requests, improve the assessment of mortgage risk or to provide more accurate insights to the company. Being RPA and IPA transparency drivers, they are good tools to help mitigate fraud in the financial environment, at least those associated with financial processes as erroneous payments (*View of Robotic Process Automation and Effectiveness of Financial Decisions_ A Critical Review.Pdf*, n.d.). All these functionalities are based on Artificial Intelligence and more specifically in machine learning and data mining techniques.

Thus, accordingly to the APQC PCF, there are process groups within the "Manage Financial Resources" category that can benefit from automation, e.g., "Perform revenue accounting", "Process payroll" among others.

According to McAfee (computer antivirus company), in 2019, cyber-crimes cost around $600 billion/ year to corporate finances, being fraud the principal type of delict. This way, fraud detection is a major challenge, and a significant number of companies are implementing AI algorithms to fight this problem, both through IPA applications on financial processes and through the implementation of biometric authentication to access certain devices or places (*View of Automation and Machine Learning in Transforming the Financial Industry.Pdf*, n.d.). All this can be achieved thanks to artificial intelligence and machine and deep learning techniques. Again, taking into consideration the APQC PCF, one can affirm that within the "Manage Information Technology (IT)" category, the "Develop and manage IT resilience and risk" or "Create and manage support services/ solutions" process groups should be good candidates to automation.

Although many customers prefer contact with human employees, sometimes, using machines to serve clients can be the most efficient way, both in terms of efficiency for the company and quality for the customer. The most famous format of machines attending customers are the chatbots which are usually based on Natural Language Processing (NLP) and other machine learning algorithms designed to provide a personalized service to each customer (*View of Automation and Machine Learning in Transforming the Financial Industry.Pdf*, n.d.). The purpose of this paragraph is to demonstrate that even in finance, customer service can be automated, and proof of this is that in Portugal it is usual to call a financial institution and the first contact is made through customer service software. The process category "Manage Customer Service" of APQC PCF has several process groups that could benefit from automation, namely, "Plan and manage customer service contacts" or "Service products after sales".

In a matter of capital markets, in the 1970s, the first steps on automation were done in America and nowadays, with the usage of AI, there are algorithms that can perform much faster than humans and thus are used for trading, also due to the low probability of make mistakes when compared to humans. Additionally, this software can handle data loads at once and track different markets simultaneously (*View of Automation and Machine Learning in Transforming the Financial Industry.Pdf*, n.d.).

INTERNAL PROCESSES

There are two main types of data within an organization: structured and unstructured. The first one is associated to databases and the second one can be seen as documents. Documents can be of many formats, e.g., text and can represent different things as contracts, records, acts inherent to the main activity of the company, and many others. Document management systems (DMS) are characterized by the capacity of generate, receive, transmit, store, monitor and protect documents through their life cycle (Ragimova et al., 2020). Once DMS are able to perform these activities the process category of, e.g., "Develop and Manage Products and Services" can benefit from automation, especially the "Govern and manage product/ service development program" process group accordingly to APQC PCF.

An automated and efficient documents management can help organizations in several directions. Firstly, it can save employees' time and consequently lower costs. Also, it can improve space flexibility in terms of physical location, as the more digital things are, the more flexible the workspace is (Ragimova et al., 2020) and this proved to be a necessity in today's eyes, due to the pandemic situation caused by the COVID-19 virus. Derived from this need there are the Electronic Document Management System (EDMS) that are central systems able to coordinate the subsystems in a matter of document management (Ragimova et al., 2020). These EDMS typically store documents centrally on the server and the way of work with it is through an interface implemented by the usage of a browser. It should be added that this technology is still being developed and its implementation format is still under study (Abbasova, 2020).

There are specific desirable functionalities for these systems and some of them are to provide quick and easy ways of search, store, access, and update information, as well as to guarantee the possibility to access data within all the organization, also including customers or other stakeholders, via Internet. All these benefits should coexist with a robust security of the information (Abbasova, 2020), ensuring availability, confidentiality, and integrity.

Regarding the "anatomical features", a good EDMS is smooth in a matter of integration, since it should be able to be embedded to the existing enterprise organization and systems. Another key aspect is the possibility of the system to correctly distribute the information, this is, make it available for the right people or machines even when simultaneously used. This distribution could be done through an internal network. Since one of the goals is to make the organization more optimized and efficient, it is beneficial to guarantee the workflow automation of the documents' routines in order to optimize the business processes (Abbasova, 2020). Thus, accordingly to APQC PCF, the category of "Manage Information Technology (IT)", mainly the process group of "Create and manage support services/ solutions", would benefit from this solution.

HUMAN RESOURCES (HR)

As in all the areas mentioned, the goal of automate HR department is to increase its efficiency, while reducing costs and process time, allowing employees to focus on more complex tasks where the human input is valuable. HR is now having the opportunity to be a strategic part of the organization, integrating the business processes' digitalization and the employees' empowerment, offering them the possibility of performing tasks with greater added value (Papageorgiou, 2018). Beyond this, COVID-19 pandemic boosted HR automation as the work of all organizations had to be reinvented and human resources are at the heart of a company's support.

Regarding the recruitment process, many organizations are using automated formats to make the process more efficient through the use of AI and ML to match candidate´s profile with the open position. This is typically done through the usage of intelligent bots. Besides this, the analytical component on the HR departments is increasingly present in everyday life, in order to let HR employees collect and easily interpret data from various sources and move straight to the organization goals. Some of the most famous processes, susceptible to apply analytical capabilities are the ones, e.g., related with management and payment of salaries and allowances or productivity and performance control. RPA has also achieved its importance within the HR domain, as many processes, nowadays, are automated by these systems, instead of being performed by humans. Learning and Development (L & D), employees' holidays management, routine tasks, e.g., read, insert, or update certain employee, customer or firm records are the most common candidates to be targeted for RPA by HR (Meduri & Yadav, 2021).

According to APQC PCF, the process category of "Develop and Manage Human Capital" can benefit from automation, specifically the process groups of "Develop and manage human resources planning, policies, and strategies", "Recruit, source, and select employees", "Manage employee on boarding, development, and training" and others.

Despite it still being an under-used resource, AI and ML will increasingly emerge in HR in order to extend what is currently done by RPAs. Thus, the objective is to enable the introduction of intelligence to these machines, so that, in addition to performing pre-defined tasks, this software is able to think, judge and perceive in a similar way to us, humans.

2.2.3. Challenges & Opportunities

With the emergence of new technologies, there is also a set of challenges and opportunities that the working world must explore. Some of these opportunities and challenges are inherent to a specific business area but most of them are cross-cutting.

RPA is already a relevant tool in the financial area for the reasons mentioned above, but IPA – which can be basically described as an RPA with smart capability – despite its benefits being known, has not gained dominance yet (Gotthardt et al., 2020). Whoever says IPA can also refer to something more grandiose, like hyperautomation that allows end-to-end integration (Mühlberger et al., 2020).

Some authors defend that RPA lacks in the capability of truly transform business processes and, instead of it, RPA only reduce errors, time and costs being referred as "quick wins". In a broader perspective, one can say that this tool fails with regard to integration, once it only operates in isolated activities, so it is at a disadvantage when compared to the tools already embedded in the core of the enterprise. Additionally, RPA is prepared to deal with structured data (Syed et al., 2020) and it is from the common sense that not all the data is structured, e.g., many documents can be based on text or even voice. Here it is possible to percept the need for hyperautomation, this is, intelligent automation end-to-end.

This can be seen both as a challenge and an opportunity to improve processes' optimization and automation in corporate finances, industry, HR and others. The implementation of IPA allows to enjoy the benefits of AI and ML and thus providing features such as a greater capacity for interaction both with other workers/ systems and regarding customer service and relationship or better monitor the Key Risk Indicators (KRI) very used in the corporate finances (Gotthardt et al., 2020). These are mere examples, once many more activities can benefit from the addition of intelligence.

An important step to take in the intelligence field for process automation – and transversal to almost all the industries and not only finance or HR – is the adoption of Natural Language Processing (NLP) through the usage of AI, more specifically, ML, which could allow to partially replace the tasks done by human employees regarding customer's relationship. Going further, RPA can also be integrated with capabilities of computer vision or cloud integration (Syed et al., 2020).

In addition to the importance of integration and intelligence, the governance in automation subject is also a key topic for the challenges in this area. When using RPAs, companies must be aware that if their way of work is systematic, if they make mistakes, these mistakes will be systematically executed too. It should exist an extra attention when the business environment/ rules change. This way, there is the need to improve the testing and monitoring activities in a matter of automated machines, so it is necessary to understand the importance of RPA/ IPA governance and rigorously manage it (Gotthardt et al., 2020). Also, since rules in the business environment tend to change with a certain frequency, the need for a more integrated solution is increasingly notorious, since once all the systems and processes are connected the probability of communication failures within the organization decreases. Also, this integration would allow robots to monitor themselves (Syed et al., 2020). Once again, we fall in need of hyperautomation.

This theme brings us to another topic of greater importance which is the issue of security, again for all industries, since whether all companies have sensitive records. It is necessary not to forget the vulnerabilities of the data and systems in question with regard to crimes and for this reason the greatest transparency of the automated software must be guaranteed (Gotthardt et al., 2020). There are several solutions available to mitigate this concern, being them to ensure a solid logging and auditing, to implement a good methodology for password and user authentication and it is also imperative to assure a robust network security (Syed et al., 2020) – this can be done through computer security protocols as well the implementation of powerful authentication requirements –.

Although RPA benefits are well known by most of the companies, the addition of a machine like this – or like IPA or hyperautomation – is not properly measured in terms of value added. On the contrary, sometimes due to lack of position understanding and guidance the implementation of automation does not show the expected benefits. Similarly, there are also no good measures – stages – for the adoption of automation, for example, by discipline within the company (Syed et al., 2020), e.g., it should be measured the effect of adding a robot in the quality of work of a specific department.

This forwards us to the need for a framework that presents maturity levels to assess organizations in a matter of automation maturity enabling companies to position themselves and understand what is needed, in order to take the next step in the automation journey, having always into consideration their goals, since what is a good automation step for a company can be a waste of resources for another. In fact, the same company can be in different levels of automation for different subjects or departments, and it can make sense or not (Syed et al., 2020).

Specifically, for the HR department, the emergence of automation is raising a problem which is related to the reticence from employees (Syed et al., 2020) due to their uncertain about the continuity of their careers (fear of being replaced by the software). This way, it is important to motivate employees in this journey and companies must rethink employees' roles, once some of them can be replaced by automation. On the other hand, robots offer the opportunity to create new jobs for humans, e.g., around the robots' manipulation/ supervision and all the analytics surrounding this software (Syed et al., 2020).

On the industry field, one can point several technologies that can be considered a challenge, mainly for Small and Medium Enterprises (SMEs) operating over industry. In addition to the already very used RPAs software, industrial companies are invited to implement virtual simulations, as well as Augmented Reality (AR) and Virtual Reality (VR) for training and process monitoring. Going to a more sophisticated level, these companies face the challenge of implementing Internet of Things (IoT) on their process which also gave the opportunity to retrieve more insights on production (Grube et al., 2017). IoT can be seen as a connection of all the "things" through an Internet connected network, in this case, within an organization, and a famous enabler for IoT is the Radio Frequency Identification (RFID) technology and its efforts can help, e.g., in the resource planning or logistics (Grube et al., 2017). RFID works having on its basis the radio signal being able to handle data remotely. This way, the big challenge for industry is to become "smart" and it means customer-oriented intelligent organizations (or factories) with a great capacity for automation, integration and connectivity. In order to achieve this goal, several technologies must be taken into account being them AI with special attention to ML and Deep Learning (DL), Blockchain, hyperautomation, and IoT (Seungjin et al., 2020).

2.2.4. Technological Approaches

In the following paragraphs, it is presented a contextualization of the main existing technological approaches in the scope of process automation.

2.2.4.1. BPMS Integration

Nowadays, taking into account the volatility of the business environments, the processes must be agile (Bider et al., 2014). BPMS – Business Process Management System (or suit) – can be characterized as a software environment for the integration of an organization's processes life cycle where it is possible to monitor and improve processes, while experiencing the benefits of the connection. Thus, BPMS can be seen as a support technology to integrate BPM initiatives (Paim & Magalhaes, 2009). In order to provide integration between diverse activities, BPMS need to be align with the enterprise architecture, so they are frequently combined with other IT-Information Technologies, tools as SOA – Service Oriented Architecture. In 2012, Gartner have defined BPMS has one of the most relevant emerging technologies, since this tool can handle the organization's workflow, while connecting it with Business Intelligence (BI) solutions, engines, and business applications (Bider et al., 2014).

BPMS integration can include besides the process itself, organization´s systems, tools, process actors (participants) as well as events (Paim & Magalhaes, 2009). For its proper functioning processes, must present information about the tasks from which they are composed, as well as a specification of start and end events conditions. One can say that an instance is a single execution of a certain process and when diverse instances are simultaneously running a BPMS is needed to coordinate and control the activities (Paim & Magalhaes, 2009).

Effectively, BPM and BPMS have similarities, as they both aim to optimize business processes through automation (Santos et al., 2007). However, their differences can be verified. According to Arora, BPM stands for describing the needed tools and methodologies to enable enterprises better modelling, optimizing, and monitoring their business processes, while BPMS have the goal to orchestrate business processes with themselves, as well with the actors that may be systems or human employees, in order to increase the integration and consequently the optimization and control (Santos et al., 2007).

2.2.4.2. Workflow Automation

Workflow automation was a dream among the working world in the 1970's, since there was a huge desire of reducing paper and automate office tasks. This way, workflow automation technology was developed at the end of the 20th century, in order to cover this need (Stohr & Zhao, 2001). The concept evolved in a way that the goal is not to automate isolated tasks, but the whole process, and for this reason a successful workflow automation implementation should reduce process' cycle time and costs while increasing accuracy and process architecture manageability (Stohr & Zhao, 2001).

Workflow can be defined as a business process automation format and can be considered both in a whole or partial perspective. The aim of this tool is to optimize processes through, e.g., minimize handouts between process actors, providing them an automatic alternative to transmit information and documents. Workflow automation, as expected, is based on pre-defined business rules and sequences and the transactions between steps are done by the mean of an Information System (IS), which, in this case, the proper name is Workflow Management System (WfMS) (Stohr & Zhao, 2001).

WfMS already recognized the need of expertise in this labour division. This way, these systems forward the tasks to the responsible actor while providing access to the respective software and information and coordinating the flow of the activities between actors (Stohr & Zhao, 2001).

2.2.4.3. RPA

Robotic Process Automation (RPA) is the proof that the robotics era is happening now, in truth, it is happening since the 2000s and in the past years this topic has attracted the companies' attention (Hofmann et al., 2020).

RPA can be characterized as a software machine designed under well-defined business rules (if, then else) and it is suitable for routine and monotonous tasks (Moffitt et al., 2018). In other words, RPA software operate in Graphical User Interfaces (GUIs) of other platforms, as humans would do, and are able to deal with structured data using a combination of GUI dynamics or using a connection to APIs, in order to work with client servers, accordingly with Gartner (Aalst et al., 2018). Often, when companies weigh in the balance the cost of having human resources or the cost of implementing a BPMS versus the business needs, they conclude that RPA fits the situation being it an intermediate between human work and BPA (Hofmann et al., 2020). In a nutshell, RPA is a software which aims to relieve employees of repetitive and simple activities (Aalst et al., 2018) and are able to automate isolated and low mental effort tasks (Hofmann et al., 2020).

Once robots brought the possibility to reduce the errors, the costs, the processes' performance time and thus increasing efficiency, organizations need to rethink the functions performed by their employees (Hofmann et al., 2020) and they probably would find useful to assign more complex tasks with the need of intellectual judgement, creativity, communication skills (Hofmann et al., 2020) or tasks with frequent uncertain outcomes to employees since RPA machines are not ideal to perform work with this nature (Aalst et al., 2018).

The simplicity of RPA can be understood having in mind the required steps to successfully conduct a RPA project (Nitzsche & Norton, 2009):

1. Determine candidate processes.
2. Model the routines through a flowchart diagram.
3. Record the events happening in the UI while managing by a human in order to mimic it.
4. Develop the necessary code to perform those routines.
5. Deploy the created machines in their correspondent work environment.
6. Monitor the performance of the machines.

RPA is a revolutionary tool for process automation, but it is not a good approach to use it alone, instead, it should be combined with other process optimization tools (Hofmann et al., 2020). In our day-to-day life we can percept that things are as good as we made them, so the same happens with these technological tools. There is a clear logic in optimizing processes before applying RPA in order not only to get the best out of the robot but also to enhance the identification of processes applicable to RPA (Hofmann et al., 2020). Despite all the fascinating RPA capabilities, it also has some handicaps, being them the need of collecting the right information or the need to handle the exceptions about the business rules while managing the automation through the whole organization (Mühlberger et al., 2020).

It is common to defend the combination of BPM initiatives with RPA usage, but there is lack of efficient implementation suggestions in the literature. However, there is a complete approach developed in 2020 (Mühlberger et al., 2020), which includes the architecture for the integration between RPA and BPM. This way, the authors defend to build a bridge between the two tools, offering the ability to run automated activities using RPA during the execution of BPMS, without human interaction where process designers must define the input and output for the processes. Below, it is possible to observe the proposed architecture.

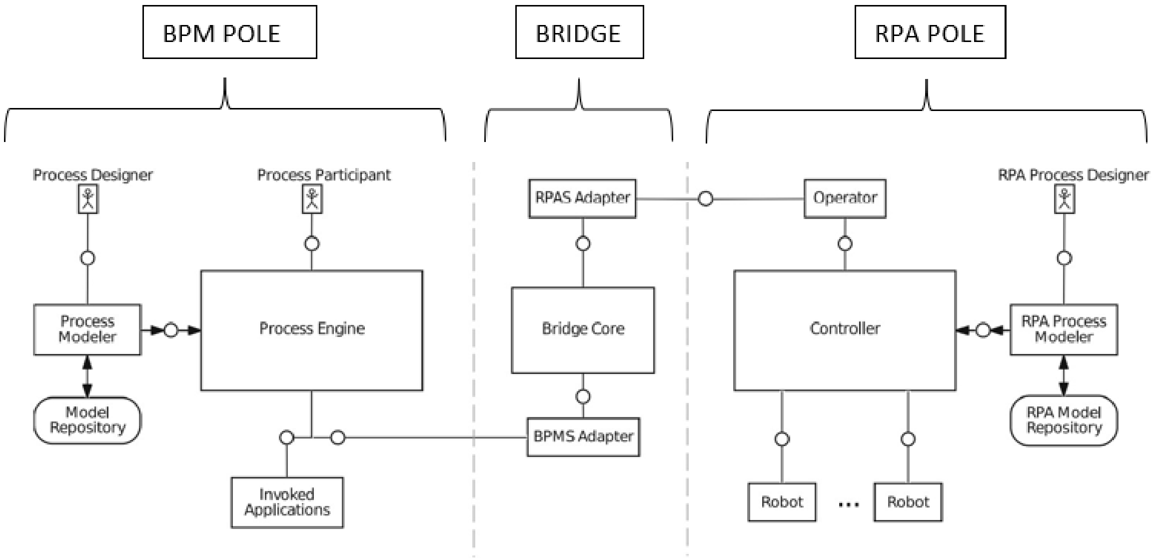

Fig. 6 – Integration of BPM & RPA (Mühlberger et al., 2020)

According to the authors of this proposal architecture, the controller in the RPA pole aims to orchestrate the robots with each other as well as distributing the appropriate tasks to each of them and the BPMS do not know each of the robots since the controller is just an intermediary. Thus, the separation of responsibilities is guaranteed. When irregularities or exceptions are detected, the instances are forwarded to the BPMS, in order to handle them. Each time an instance starts running in the BPMS, the activity is delegated to a specific adapter which links to the correspondent RPA adaptor providing input to that standardized RPA process input format, In the RPA pole converts the RPA output into a standardized process result format to be transferred to the Bridge Core and then to the BPMS adapter (Mühlberger et al., 2020). The study ends with a prototype implementation in a use case scenario to evaluate the solution effectiveness which turns out to be confirmed as a viable option to alleviate RPA limitations.

Another interesting point to highlight is related with the different variables used to classify the RPA tools. One can distinguish the market offers through the software architecture, which can be Client-Server or Stand-Alone (Nitzsche & Norton, 2009). Regarding the code, it can be divided into three levels, being them Strong Code (need solid programming skills), Low-Code (combine the usage of drag and drop with low-coding) and GUI (mainly using drag and drop functionality). Another characteristic is related with the machine learning abilities, which can be attended when robots interact with humans through their working process, unattended when robots can act without human intervention (Hofmann et al., 2020) and hybrid when attended an unattended capacity are combined (Nitzsche & Norton, 2009). Another great indicator to classify RPA tools is the produced logs quality, some authors using the MM of Process Mining Manifesto to classify RPA logs quality. This MM assign the connotation of “Poor quality” for the ones positioned in the first level and “Excellent” for the fifth position (Nitzsche & Norton, 2009).

Despite all the benefits of RPA, the world is seeking for intelligence in robots so they can judge and handle more complex situations. This is where the IPA concept appears (Mühlberger et al., 2020).

2.2.4.4. IPA

Intelligent Process Automation (IPA) can be defined as an RPA software with extended capabilities, which include the ability to judge and deal with unstructured data, since intelligence is embraced (Devarajan, 2019). Thus, one can affirm that IPA combine process optimization techniques with RPA functionalities, adding AI and ML to the game, also using cognitive technologies as Natural Language Generation (NLG) and, e.g., cognitive agents that combine ML with NLG (Berruti & Taglioni, 2017). IPA can also offer tools as, e.g., Natural Language Processing (NLP), Computer Vision or Speech Recognition (Devarajan, 2019).

Besides the automation of simple and repetitive tasks, IPA automation is more complex and allow the machine to perform decision-making tasks, generating and taking into consideration insights based on its analytical capability, using data that can be collected from multiple sources (Devarajan, 2019). In addition, the promise of IPA is to be able to coordinate and boost the collaboration of multiple IPAs software. As human employees are still being an essential part of organizations, IPAs cover the need to connect and integrate the work between humans and machines, so that they coexist in an efficient work environment. However, IPAs are able to accommodate the entire cycle of a process and even promote its improvement, allowing itself to learn from its previous performance (Mühlberger et al., 2020).

In contrast to RPAs, in order to verify which processes are candidates for IPA, both structured and unstructured data must be taken into account and thus this process itself is more complex. Regarding implementation costs, IPA tends to be expensive comparing with RPA, since the preparation of data takes more time and is more arduous. Also, the cost of maintenance increases due to the AI usage, since models must be updated accordingly with changes in the working environment (Mühlberger et al., 2020).

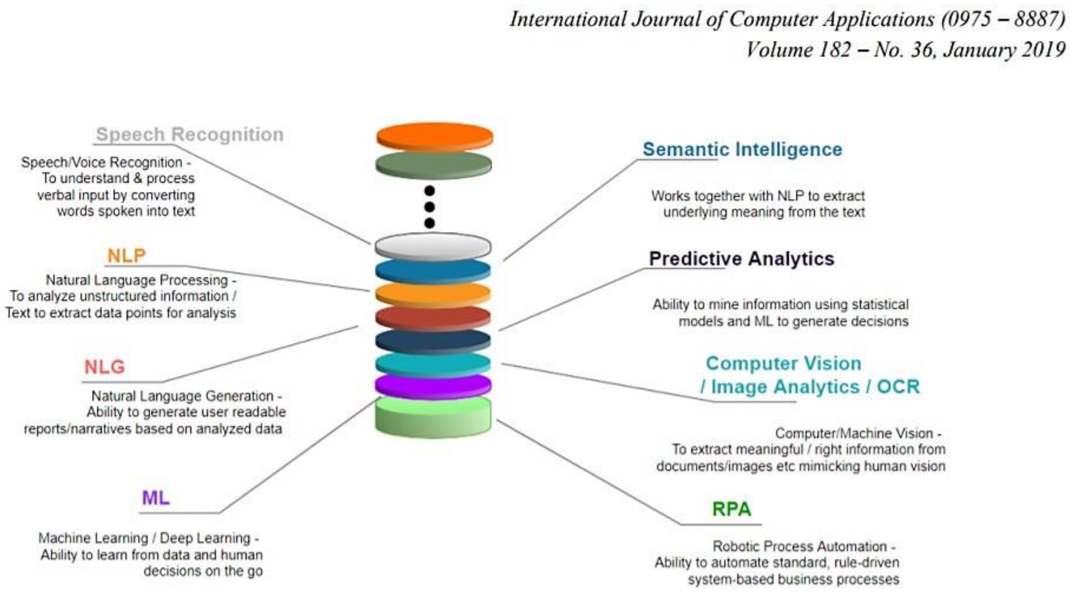

Fig. 7 – IPA elements (Devarajan, 2019)

Real-life examples of IPA usage in process automation improvement can be related to, e.g., recommender systems that are widely used by retailers and combine AI and ML efforts to suggest products to a customer, based on their previous interactions (Devarajan, 2019) or by relating that customer with a similar one. Another example can be the very well-known chat bots which combine AI, ML, Semantic Intelligence and NLP to interact with customers (Devarajan, 2019).

2.2.4.5. Hyperautomation

As already mentioned in the present document, Gartner positions hyperautomation in the first of the top 10 strategic technology trends which promise to disrupt the way of work in this decade (Lasso-Rodriguez & Winkler, 2020b).

Hyperautomation is a technology for process automation, based on BPM techniques of optimization and benefiting from the latest robots' state of the art (IPA), in order to achieve a level of automation where machines can fulfil jobs from the beginning to end without human interaction (Lasso-Rodriguez & Winkler, 2020a), this is, end-to-end automation.

Some authors see hyperautomation as an extraordinary way to transform business processes which guarantee solid and flexible outcomes due to is ability to connect several technologies around RPA/ IPA, creating an integrated work environment. However, it is important to keep in mind that processes must be already optimized to retrieve the maximum benefit from this type of software. Also, the cost of implementing and maintaining hyperautomation is higher than the previous technologies presented above and organizations must assess their situation, in order to both understand if the effort makes sense in that specific context and, if so, what are the best features and way of implementation to proceed (Lasso-Rodriguez & Winkler, 2020a).

Lasso and Winkler (2020) performed a study that aimed to answer whether or not an hyperautomated solution can replace a BPM manager role. Of course, BPM manager functions may differ from one organization to another, but in general it can be said that for this job, besides the technical know-how, there is the need of transparency, communication/ empathy, ethics, resilience, flexibility, as well as a great ability for hard work when the situation demands it. Considering the need for a BPM manager to have empathy and communication skills, it can be considered that a machine with NLP functionalities will be able to perceive, e.g., the employees' mood and act accordingly, in this way the benefit that these robots can bring is notorious. Besides this, it is also important to highlight that robots are not vulnerable to illnesses, moods or fatigue and stress and therefore constitute a workforce with exponential benefits. The methodology for the study was to perform a survey with 33 experts in RPA, process management or AI from the five continents. Opinions are divided, since there is a part that believes there are functions that should be performed by humans due to, e.g., emotional intelligence. However, at the end of the study, 61% of respondents consider the possibility of an hyperautomated robot replacing the BPM Manager role in an organization (Lasso-Rodriguez & Winkler, 2020a).

Anyway, this can be considered as a proof that in addition to being possible for a machine to automate end-to-end processes, people, who in this case are the surveyed experts are starting to have more confidence in the implementation and use of these solutions. Hyperautomation is undoubtedly a winner of process automation in the current era.

An important topic to approach is the lack of defined strategies and measurements to implement hyperautomation by the enterprise architecture (Ray et al., 2019) and thus this gap should be fulfilled.

2.2.4.6. Process Analytics

Business Process Analytics (BPA) is a discipline that can be seen as a complement to Business Process Management systems (BPMS), since the insights of the analytical component can be inserted in the flow of BPMS, in order to better monitoring the processes and, consequently, improve them.

In other words, Business Process Analytics uses business data to support in the decision-making activities, enabling an organization to improve their processes' efficiency,

The value of analytics can be used for numerous purposes, in terms of its application in business processes. Thus, this technique can be used to evaluate the flow of a process, so that bottlenecks, gaps, or inefficiencies can be identified, as well as to simulate changes in processes and project their "What-If" effect (Abarca, 2021).

Quoting Dumas, there are six stages on the BPM life cycle:

1. Process identification.
2. Process discovery.
3. Process analysis.
4. Process redesign.
5. Process implementation.
6. Process monitoring and controlling.

For a better conception of the 3rd and 4th step, it is necessary to use Process Analytics, so that, as far as the "Process Analysis" is concerned, it is possible to identify, effectively, what is going well and what is wrong, based on metrics capable of evaluating, for example, where the process is taking time inefficiently (Izzaty et al., 1967).

On the other hand, in the "Process Redesign" step, the analytical component can give a great boost to reach the next level, as it allows to run simulations of changes to the processes, for example, through the "What-If" strategy that can be applied.

2.2.4.7. Process Mining

This concept began in the 1990s, with the premise of providing a set of techniques able to improve a process model, based on the data logs stored in an information system.

Process Mining (PM) is a rising discipline which the goal is to understand processes and to enable the acquisition of powerful insights during the execution of process activities (from a given process instance), through the extraction of event logs directly from the systems' databases, rather than just observing the tasks' behaviour (Garcia et al., 2019).

Thus, Process Mining outcomes can be interpreted as a picture showing the state of the art of business processes performance and consequently can be useful to identify issues (Ferreira, 2017)

Process Mining can be seen as an opportunity to boost Business Process Management techniques already in place in an organization, since the main goal of PM is to create a solid process model and identify the issues during tasks' execution and its cause and consequences.

On the other hand, there is the data mining subject whose main objective is to find data patterns and, consequently, aggregate data through those findings. This way, for Aalst, the Process Mining discipline is positioned between Business Process Management and Data Mining, as it analyses process data to get insights and, consequently, improve the process model (Garcia et al., 2019).

Thus, Process Mining studies the tasks, in order to:

- Understand the current process model.
- Improve the process flow, by identifying gaps, bottlenecks, as well as through performance evaluation and, if possible, taking into consideration the resources, executing the activities and the respective timestamps.

(Ferreira, 2017; Garcia et al., 2019).

Process mining describe procedures of refining structured and defined processes, based on data retrieved from the business activities themselves (Garcia et al., 2019).

According to Ferreira, the event logs can be used to manage three PM typologies:

1) Process discovery: through an event log, producing a model based on the actual function of the instances.

2) Conformance: an already existing model is compared with itself by analysing an event log of itself. The value of this second feature – Conformance – is that it allows checking whether the reality of the process is in compliance to the model.
3) Process enhancement: the improvement of an existing process model, using the data, transformed into information, regarding the current process through the stored event logs, e.g., using timestamps in the event log, it is possible to identify bottlenecks or activity frequencies.

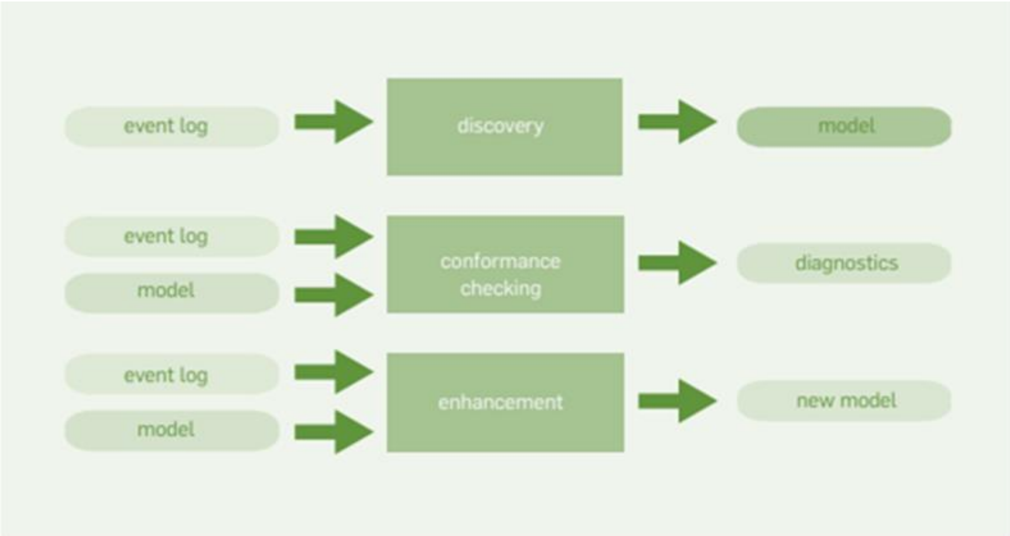

Fig. 8 – PM Outcomes (Ferreira, 2017)

According to Aalst, Process Mining can be used as an enabler for process automation, since its transparency can guide the Organizations in the identification of opportunities.

This way, PM, together with Artificial Intelligence and RPA, constitutes space for a new, and more efficient, working approach. Through the usage of Process Mining, it is possible to empower the employees, allocating their capacities in other tasks (Aalst, 2012).

2.2.4.8. Process Auditing

Process Audit is a technique used to analyse the procedural flow of a business process, enabling the assessment of processes functioning and, consequently, the providing of recommendations for improvement.

The process audit can, and should, be used as an internal tool, so that the organization is aware of the operability of its processes, so that it can evolve and correct identified flaws.

The first step to conduct a process auditing is to delimit the scope of the analysis, i.e., to define the process in audit, as well as its constraints and limitations, in order to produce a more targeted study.

Typically, in an audit, a list of occurrences is extracted directly from the information system and, with the support of a random generator, select x occurrences to prepare a sample. Then, the evidence corresponding to that sample is analysed and gives rise to the audit conclusions.

However, this approach has a risk: if from a population of 10,000 occurrences a sample of 25 is selected – which is a number used by audit standards for large populations –, many cases are being ignored and they could change brutally the audit conclusions and consequent recommendations.

Nonetheless, it is understandable that 10,000 occurrences are not analysed manually, due to the time required, as well as the reason that human error would be very susceptible.

Thus, the ideal would be a solution that contemplates the integrity of the population as well as being characterized by efficiency in terms of time and errors.

As previously mentioned, namely in the Process Mining section, the activity logs illustrate the process behaviour in a real-time approach. According to Kurniati, the PM can be a valuable asset in process auditing within an organization.

This way, to Kurniati, a company should delimit the processes in scope and evaluate how can the event logs support the process assessment, in order to understand the suitability to apply the PM methodology (Kurniati et al., 2015).

However, even if the process is not suitable to apply Process Mining, it is still a good approach to audit the process with the tools available, even though documented evidences or walking through the processes along with the employees in charge of them.

2.3. Maturity Models – MM

Since the output of the present dissertation will be constituted by a Maturity Model, it is important to provide some context and development in the field of Maturity Models, especially in the business processes environment. Thus, this section includes a study on some of the most relevant Maturity Models existing within the scope of the topic addressed in this paper.

2.3.1. Concepts

2.3.1.1. Ontology

The concept of maturity, when applied to processes, is used to express the capability of an organization to improve and deliver better outcomes from their processes. Nowadays, MM are essential for the success of an organization, but this concept is not new, as it originated in the 1970s in the head of Philip Crosby (Gabryelczyk, 2018).

As already mentioned, in the contextualization section of the present document, a Maturity Model (MM) can be described as a tool or guideline to enhance the processes' optimization within a company and can be also seen as a descriptive tool (Röglinger et al., 2012a), since it allows enterprises to be positioned in a certain level regarding a certain subject.

Thus, the goal of MM is to orient enterprises through the journey, towards the optimization of processes. In order to achieve this ambition, there is the need to define distinct stages regarding process optimization from the bottom – where optimization course is in the beginning – to the top level – where there is excellence in the optimization. However, the position of organizations is important, there is also a need to help them move up to the next stage, fulfilling their inconsistencies and improving their efficiency. Thus, a MM should position organizations and guide their improvement (Proença & Borbinha, 2016). This way, it can be said that the MM have three main purposes, which are: to describe the *as-is* situation of the optimization of an organization's processes, to guide enterprises in improving the optimization and to allow the comparison of an organization with others or even to compare different departments in the same organization (Roquete, 2018).

2.3.1.2. Taxonomies

MM are composed by different maturity stages and each of these stages corresponds to a taxonomy, this is, a set of different characteristics. In order to achieve the next level, an organization must complete all the requirements from the current level – to be mature – and the ROI should be at least the expected (Roquete, 2018). Usually, this tool has an incremental nature where more advanced levels incorporate the features of previous levels while adding new goals.

Once investigating the literature, it can be confirmed that many authors choose to define five or six levels of maturity, being the 5th/ 6th the most advanced. Besides those levels, MM usually evaluate different dimensions within organizations, e.g., employees or daily operations. It is important to highlight that the different maturity levels allow organizations to balance *cost vs benefit* of each stage, in order to understand what the most suitable solution is to fulfil their needs.

As an example, the levels of the Acatech MM, which is related to digital transformation – industry 4.0 –, can be taken into consideration. This MM is characterized by six different stages where the first one is the least evolved. Acatech MM acts in a total correlation with organization's goals and is based on sequence of taxonomies able to evaluate the current state and guide the enterprise to the next step. Acatech is a multidimensional model, this is, takes into consideration different components to assess a company. Those components are the resources, IS, the organizational structure and the enterprise's culture (Dombrowski & Dix, 2018). Below, it is possible to observe the six different levels defined in Acatech.

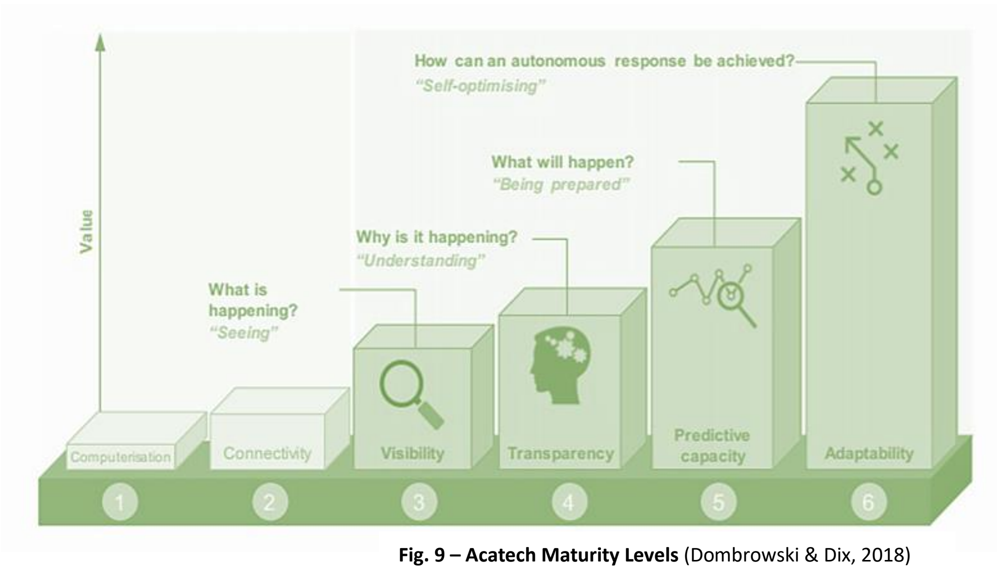

Fig. 9 – Acatech Maturity Levels (Dombrowski & Dix, 2018)

Impuls is another example of MM applied to industry 4.0. This model assesses organizations' ability to prepare for the digital transformation journey and ranges from level 1 – outsider – to level 6 – Top performer –, being this the most advanced. Impuls takes into account six components to measure the organization's readiness – to digital transformation –, being them Strategy and organization, Smart factory, Smart operations, Smart products, Data-driven services and Employees. Similarity to other MM, Impuls' goal is to position and help companies improving from level to level (Rajnai & Kocsis, 2018). In the figure presented below it is possible to verify which stages make up this model.

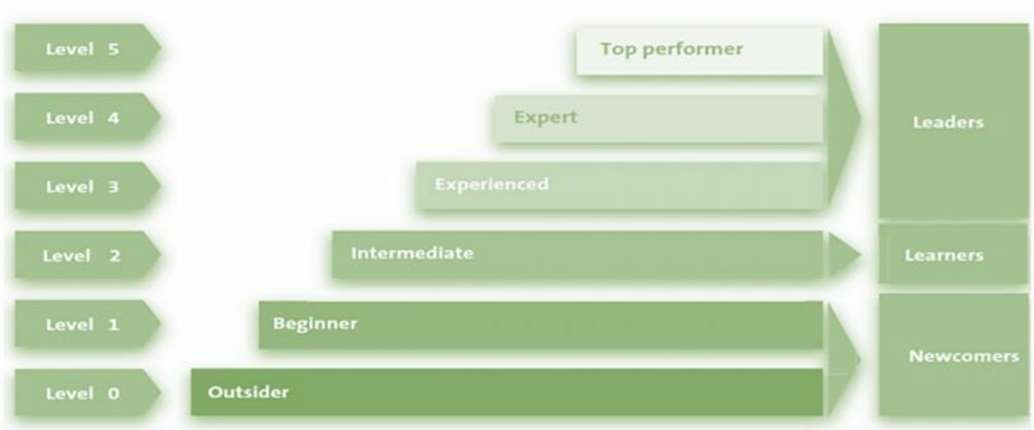

Fig. 10 – Impuls Maturity Levels (Rajnai & Kocsis, 2018)

In a further section of the present document, MM regarding BPM will be presented and one can verify the standard of having five or six maturity stages per model.

In a nutshell, taxonomies – maturity levels – have the goal to summarise the situation of one factor in a well-defined scope (Rosemann & Bruin, 2005).

2.3.2. CMMI

Despite the existence of different maturity models, companies face orientation difficulties and, to overcome this obstacle, it would be necessary to have a MM that integrates the performance and maturity assessment of organizations, taking into account several dimensions (Roquete, 2018). In 2006, the Software Engineering Institute (SEI) launched the Capability Maturity Model Integration (CMMI).

CMMI can be defined as a MM or framework that offers the best practices to orient companies in business processes' improvement, namely in software development and implementation. CMMI can also be used to perform comparisons – similarly to the MMs previously mentioned – (Saeed et al., 2017), including comparisons with other frameworks, e.g., Agile (Pane & Sarno, 2015).

CMMI aims to define Process Areas (PA) to develop software and, after that definition, the model seeks Specific Goals (SG) within those areas. Since the SGs are known, the CMMI determines the Specific Practices (SP) in a well-structured manner in order to achieve the SGs. The CMMI described is, more specifically, the CMMI for development (CMMI-DEV) which is based on the three components mentioned before: PA, SG and SP (Khraiwesh, 2020). This MM applies stages – maturity levels – to describe where is the organization positioned and what improvements are needed in the defined PAs (Pane & Sarno, 2015). According to Alqadri (Alqadri et al., 2020), The CMMI-DEV has several benefits, namely:

- Time-to-Market improvement: effectiveness in delivering products/services, avoiding re-work.
- Quality & customer satisfaction improvement: defects reduction due to increase of consistency.
- Cost reduction: due to the provision of a consistent plan with defined schedules and budgets.
- Product life cycle management: management of the entire life cycle including delivery and maintenance.

All these factors contribute to increase the organizational agility and so the revenue due to the reduction of costs, quality improvement and time management (Alqadri et al., 2020).

However, there are two more types of CMMI: for acquisition (CMMI-ACQ) and for services (CMMI-SVC) (Pane & Sarno, 2015). In a nutshell, CMMI-ACQ offers a set of guidelines to help companies acquiring products or services (Carnegie-Mellon-SEI, 2010), while CMMI-SVC allow organizations to guide in the activities related with providing services (CMMI, 2010).

Being CMMI a reference model, it does not specify an integral footprint of how to implement the practices suggested by the model. This way, organizations have flexibility to decide the development approach that best fits their needs (Ayyagari & Atoum, 2019).

The CMMI is defined through five maturity levels, with the 5th being the most optimized. Level 1 characterizes processes able to fulfil the minimum of needs and, thus, presenting an inconsistent performance. Level 2 allows processes to be repeatable, this is, some efficiency is included, and performance issues begin to be solved. Level 3 indicates some proactivity, since the processes are already standardized within the organization and monitoring/ measurement activities are added, in order to achieve the purposed objectives. Level 4 embraces processes that are already significantly managed – optimized – and are able to predict and improve performance quality. The last level – 5th – stands for the excellence, where the use of statistics and other quantitative techniques is imperative and processes are not only optimized, but are in continuous improvement (Sreenivasan & Kothandaraman, 2019). In general, it can be said that the CMMI is based on three major assessment dimensions: people and their respective skills and motivations, tools/ infrastructure, and procedures (Roquete, 2018).

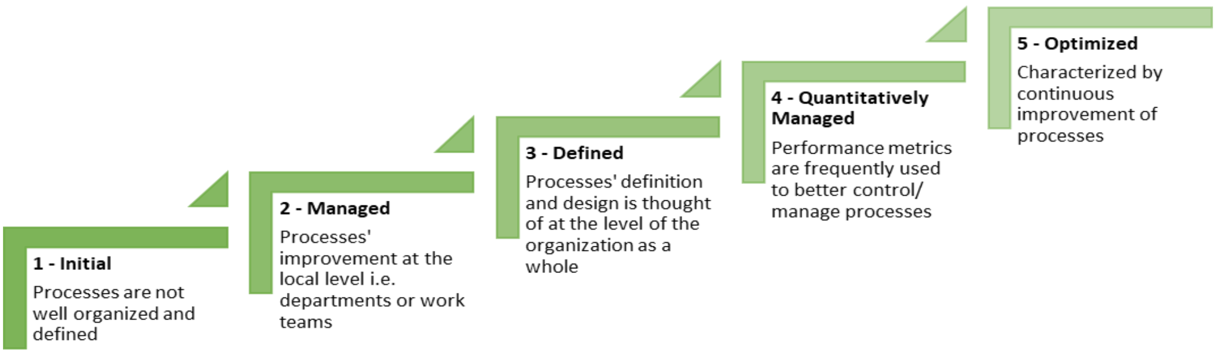

Fig. 11 – CMMI Maturity Levels (adapted from Roquete, 2018)

It is commonly said that models are projections of reality, and it is important for organizations to understand the role of project teams in implementing these types of models, since their results are only as good as those who shape them. Thus, a study was done by Tsai (Tsai, 2021) and it reveals that six main components of the organizational culture are from major importance for a successful CMMI journey, being them, “position on reform, centralization and coordination, position on collaboration, rationality and truth, motivation, and position on task”. It is also important to highlight that companies must be aware that the journey through the CMMI might be long and costly (Keshta, 2019). This way, it is necessary for organizations to previous define their goals and fit the model to them.

2.3.3. BPM Maturity Models

Organizations look at processes as a manageable asset from which the objective is to make the best use of it. For that reason, in the present century, MMs directed towards a BPM approach have started to emerge, being most of them based on CMMI (Pinto & Santos, 2020).

2.3.3.1. BPMMM

Business Process Management Maturity Model (BPMMM) has the goal of measure the BPM maturity in a certain organization and had its beginnings in the 1990s, but only became effective in 2004/ 2005 by Rosemann.

This model has a holistic and multidimensional nature, being the dimensions related to factors – independent elements which reflect BPM features and are related to governance, strategic alignment, IT, and organisational culture –; maturity stages – the ones known from CMMI –; scope – including organisational entity and time –; proficiency – the level of benefit observed by BPM usage –; and the coverage – the extension of BPM within company activities.

This MM is partially based on CMMI and so its taxonomies are identical. The peak of maturity levels corresponds to the 5th position in which the greatest BPM sophistication is reached – attention that this sophistication might not be necessary for all enterprises. Two assumptions come from the use of this model: the first is that the processes’ actual performance is the dependent variable since the factors themselves correspond to the independent variables (Rosemann & Bruin, 2005).

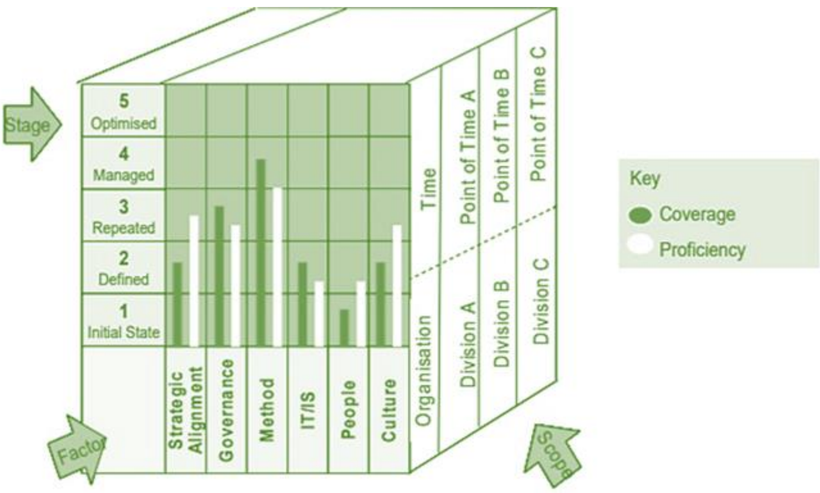

Fig. 12 – BPMM Model (Rosemann & Bruin, 2005)

2.3.3.2. BPMM Fisher

Business Process Maturity Model (BPMM) was born in 2004 and its ambition is to balance the ability to be easily related by everyone and the need of providing sufficient insights on specific actions for enterprises who strive to upgrade their processes. Thus, Fisher considers that this MM must have two key components: multidimensionality and non-linearity (Fisher, 2004).

Taking into consideration the dimensional component, Fisher has split it into two parts. The first one is known as *Five Levers of Change* and as the name itself denotes, it consists of five elements:

- Strategy
- Control
- Process
- People
- Technology

Having these five areas coordinated among them, organizations are ready to embrace the other part of the dimensional component: The *States of Process Maturity.* Consequently, the states can be defined through the following levels:

1. Siloed
2. Tactically Integrated
3. Process Driven
4. Optimized Enterprise
5. Intelligent Operating Network

As previously mentioned, the move from one stage to another is not linear. The table at right describes the *States of Process Maturity* through the *Five Levers of Change.*

	Siloed	Tactically Integrated	Process Driven	Optimized Enterprise	Intelligent Operating Network
STRATEGY	• Reactive to market conditions within 1-2 years, typically chasing a competitor • Integration within functions • Driven by cost and efficiency	• Adapt/react to market dynamics within 12 months • Some cross-functional integration to solve pains • Initial entry into point-to-point integration with partners	• Adapt/react to market dynamics within 3-6 months • Enterprise-wide process leadership is established • The business process is the foundational element of the enterprise	• Adaptive to market dynamics within weeks • Enterprise organized completely around processes • Optimized processes + execution yield competitive advantage	• Predictive capabilities and market leadership • Continuously adaptive to market dynamics in near real-time • Enterprise and its partners are organized around processes • Competitive advantage is driven and shared by partners
CONTROL	• Local and functional level authority / autonomy • No enterprise-wide standards or governance • No formal value measurement program	• Hierarchical mgmt. structure • Independent functional department decisions • Limited enterprise-wide standards or governance	• Formal process leadership establishes priorities • Business cases drive projects • Process metrics tied to individual and team performance	• Process teams responsible for overall performance • Relevant process metrics institutionalized as main performance measures	• Inter-enterprise process teams own performance • Relevant process metrics are used to measure bi-directional partner performance
PROCESS	• Static business processes • Functional silos • Geographic silos • Department focused • Informal communications within departments	• Limited process reengineering and cross-functional/process coordination (often manual, onetime efforts) • Systems drive baseline process definitions	• Fully transitioned from functional to process focus, including management structure, execution teams, and performance evaluation • Targeted BPO	• Total process integration across the enterprise • Commitment to continuous process improvement program • Outsource non-core business processes (reduce cost and increase quality)	• Total process integration across the ecosystem • Key processes flow seamlessly across firewalls
PEOPLE	• Subject matter experts • Culture is adversarial, mutual distrust • No formal change management procedures • I'll do my job, you do yours	• Cross-functional/process team members (usually led by IT) • Limited understanding of cross departmental process needs and dependencies	• Process leaders define, deploy, enhance, and maintain core processes • Functional teams focus on high quality execution	• Lean organization focused on optimizing process definitions and execution • Ongoing process training for employees	• Partner selection includes process & cultural attributes • Ongoing process training for employees and partners
IT	• Independent systems • Islands of automation • Integration only within functions • Legacy enterprise system(s)	• Leverage ERP systems for cross functional integration • Point-to-point partner integration • IT leads cross-functional initiatives (systems focused)	• IT supports process leadership team in initiatives • System and instance consolidation to streamline processes and info mgmt.	• Utilize Business Process Management (BPM) solutions to automate process execution, monitoring, and control across the Enterprise	• Utilize Business Process Management (BPM) solutions to automate and monitor process execution throughout the ecosystem

Table 1 – BPMM Fisher (Lindemulder, 2015)

2.3.3.3. BPMM-OMG

The Business Process Maturity Model from Object Management Group (BPMM-OMG) (2008) is a MM whose operation is based on the vision of managing business processes in processes' life cycle, in order to assess the maturity of activities with regard to BPM.

This MM has a strong relationship with the CMMI, since it is designed to develop SW, services or products and the maturity levels taxonomy is similar. Following, the levels are described:

1. Where there are not formal processes defined to rule de daily operation,
2. There are standards defined in order to guide the daily operation within the business units.
3. There are defined resources and processes to be followed within the organization.
4. Processes are quantitively managed in order to seek for improvement opportunities.
5. The processes are mature and in a cycle of continuous improvements.

(Roquete, 2018).

Fig. 13 – BPMM-OMG (adapted from Roquete, 2018)

2.3.3.4. BPOMM

This MM was introduced by McCormack and Johnson in 2007 and stands for understanding the maturity of business process orientation within an organization. It covers nine areas and defines maturity over four levels (Novak & Jane, 2018).

The maturity levels for this MM are, in ascending order, Ad Hoc, Defined, Linked, Integrated and the Table 2 shows the score for each stage. For the nine areas covered by this model, they can be observed in Table 3 on this page (Utami et al., 2020).

BPO Score	Level
1 – 4	Ad Hoc
4 – 5,5	Defined
5,5 – 6,5	Linked
6,5 – 7	Integrated

Table 2 – BPOMM Levels

No	Code	Area
1	Sv	Strategic View
2	Ddp	Process definition and documentation
3	mmp	Process Measurement and Management
4	Pos	Process organizational sructure
5	Uk	People management
6	Pok	Process Organizational Culture
7	Tu	Market Orientation
8	Vd	Supplier's Outlook
9	Pip	Information System Support

Table 3 – Areas covered by the BPOMM

Interpreting the meaning of each maturity stage, one can affirm that the 1st one, Ad-Hoc, stands for processes with undefined steps and where the structure remains traditional.

Regarding the 2nd level, it can be said that the basic processes are defined and include a flowchart. In the Defined stage the departments already work together to perform common processes.

The 3rd maturity level, Linked, can be characterized by the existence of coordination on the part of managers, in order to better control the process. At this level, the best practices for process flow are already defined.

The 4th level, as the name itself says, stands for integrated organizations where internal and external actors are identified and enable the organization to reach a valuable process-based work environment (Utami et al., 2020).

2.3.3.5. **PML**

Process Maturity Ladder (PML) was developed by Harmon in 2005 and is based on CMMI, since it is composed by five MM, from the initial to the optimized level. PML is built on an evolutionary and incremental concept in which improvements are continuous, i.e., it does not imply radical changes in the organization and its processes (Röglinger et al., 2012a).

The goal of PML is to introduce the habit of thinking about processes within the organization and its employees and can be characterized by its celerity instead of performing a rigorous assessment done with CMMI. The benefit of the PML model is derived from its simplicity, since it is only necessary to fill out a checklist and relate it to the respective processes. This task is done through audit initiatives, thus making the assessment and positioning of the organization/ processes (Lindemulder, 2015).

The main purpose of this model is to provide a holistic approach to process maturity assessment in an informal and easily practicable way by the members of an organization. The five levels which compose this model are (Roquete, 2018):

1. **Initial**: Organization needs to start defining the processes.
2. **Repeatable**: Moving in a positive direction, key processes are defined, and modelling tools are already in use, the organization invests in process improvement. It is necessary to articulate the processes with each other.
3. **Defined**: Processes and value chains are well-defined and there is a repository of processes.
4. **Managed**: The implementation of an integrated system for the management and metric assessment of processes is a priority for organizations in this stage.
5. **Optimized**: The focus is on continuing to improve the efficiency, effectiveness and solidity of processes and their integration.

This way, one can say that PML was designed to describe the status of an organization's business processes' efforts in a simpler way when compared to CMMI, being PML easier to interpret (Röglinger et al., 2012a).

2.3.3.6. **PCM**

This model of DeToro and McCabe, 1997, aims to assess both the maturity of processes and the maturity of the organization in the BPM field, evaluating its efficiency and effectiveness. The Process

Condition Model (PCM), a model defended by DeToro, leads to a process-oriented management that aims at better control of processes, thus avoiding bottlenecks (Roquete, 2018).

PCM relates the customer goals with a specific process and classifies it on a scale of 1-5, with the last being the most optimized stage.

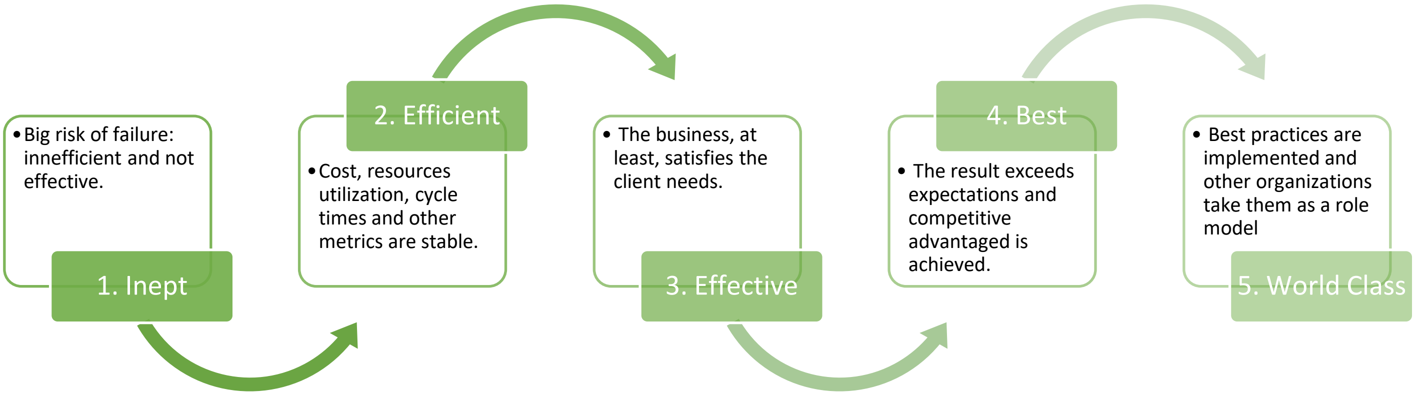

Fig. 14 – PCM Levels of Maturity (adapted from Roquete, 2018)

2.3.3.7. PEMM

Michael Hammer has a history of process re-engineering since the 1980s and, after that, he has dedicated himself heavily to the development of large-scale concepts for process improvement. It was 2007 when an article addressing Hammer's Process and Enterprise Maturity Model (PEMM) was published in the *Harvard Business Review*. In Hammer's words, PEMM "helps executives plan process-based transformations, track their progress, and identify roadblocks" (Power, 2007).

The PEMM has the particularity of distinguishing the maturity of the processes and the maturity of the organization (Röglinger et al., 2012b), through five levels – from 0 to 5. Due to the professional experience of Hammer, this model is flexible for a wide range of industries and processes.

In order to analyse the performance of a process, this MM takes into account the process enablers (Röglinger et al., 2012b), this is:

- Its design.
- The performers, i.e., the people who carry out the tasks composing that process.
- The owner of that process, i.e., the authority.
- The necessary infrastructure.
- The metrics to performance the evaluation.

To assess the maturity of the organization, the capability elements are evaluated (Röglinger et al., 2012b) and PEMM suggests the study of the following fields (Power, 2007):

- Leadership capacity.
- The culture practiced.
- The expertise.

- Governance of the unit/ organization.

Thus, one can affirm that the main purpose of PEMM is to identify key factors in companies' performance improvement. At the level of process management, the objective is to enable them (processes) in order to improve their performance; at the level of the organization, the purpose is to focus on business skills (Roquete, 2018).

One can point some limitations of this MM, being them the lack of connection between maturity and business outcomes or the lack of alignment with the organizational strategy.

2.3.3.8. SAM

Strategic Alignment Maturity Model (SAM) was launched by Luftman in 2003, and aims to help overcoming the often-known lack of connection between IT and the organization's strategy that often leads to inefficient and divergent results. In other words, SAM's goal is to assess the level of operational alignment between organizational strategy and IT within a company/ organization. Consequently, a strategic alignment with IT includes the timings' opportunity and the sharing of vision regarding the needs of the business, its objectives, and its strategies (Sledgianowski & Luftman, 2001).

The maturity levels that compose this model are similar to the ones presented in the CMMI (Roquete, 2018):

1. **Initial Processes**: alignment between IT and strategy is very unlikely to be achieved at this level.
2. **Committed Processes**: tends to be directed to enterprise's organizational functions.
3. **Established Processes**: first steps on the successful insertion of IT in the business environment.
4. **Improved Processes**: IT is already seen as a strategic component for the company's success and the focus is on improving.
5. **Optimized Processes**: excellent articulation between the company's objectives and needs and IT initiatives.

And six categories are considered (Hosseinbeig et al., 2011):

1. Communications
2. Value
3. Governance
4. Partnership
5. Scope and Architecture
6. Skills

The Luftman's model considers 12 components for structural alignment:

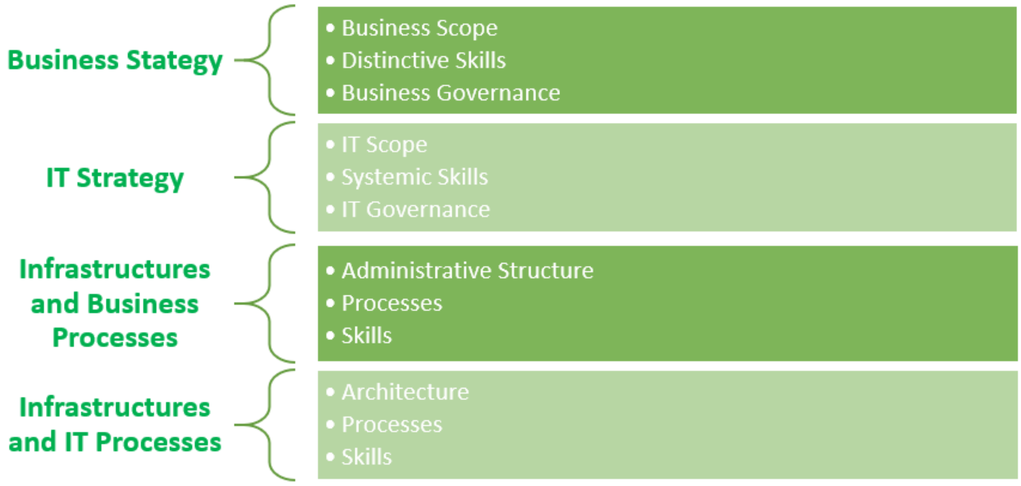

Fig. 15– SAM Structural Components (adapted from Roquete, 2018)

2.3.3.9. PMMA

Process Management Maturity Assessment (PMMA) has its basis on the CMMI, was created by Rohloff in 2009 and aims to assess the implementation of Business Process Management within an organization through nine categories, with the respective sub-categories, that the author considered impactful in BPM initiatives implementation (Rohloff, 2009).

The main goals of PMMA, besides the assessment of the maturity of all activities related to Business Process Management, are to monitor processes' initiatives and advance regarding future actions, useful to improve the implementation of certain goals in the processes and to increase the awareness for managing processes within the organization.

In a nutshell, it can be said that the PMMA is focused on evaluate the implementation of BPM initiatives within the organization instead of focusing only on the assessment of the performance of a specific BP (Rohloff, 2011).

The nine categories covered by this model are:

1. Process Portfolio and Target Settings
2. Process Documentation
3. Process Performance Controlling
4. Process Optimization
5. Program Management, Qualification, Communication
6. Process Management Organization
7. Data Management
8. IT Architecture
9. Methods & Tools

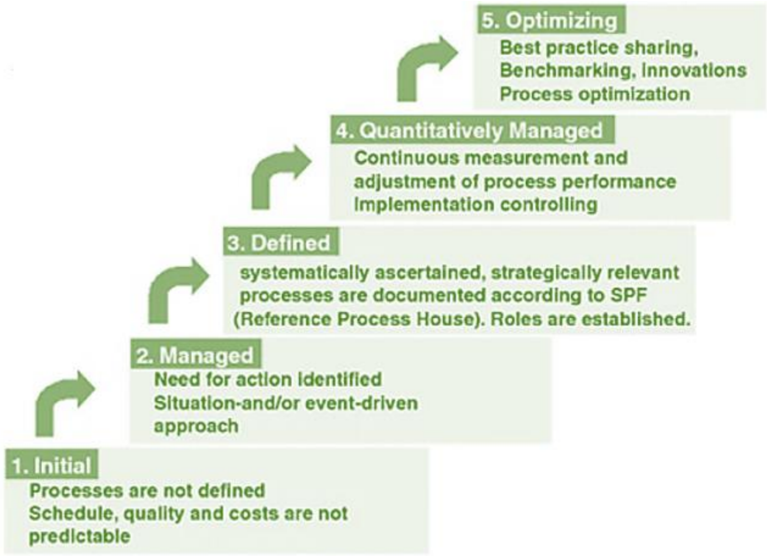

Fig. 16 – PMMA Maturity Levels (adapted from Rohloff, 2011)

2.3.3.10. BPRMM

Business Process Reengineering Maturity Model (BPRMM) by Maull, 2003, is based on the concept of process reengineering, i.e., implies a radical and revolutionary innovation and consequently involve structural changes in the organization (Röglinger et al., 2012b).

This MM is similar to the CMMI, with regard to maturity levels, as it is composed by five stages with the 5th being the most optimized and focused on specific business processes.

According to Maull, there are two major elements for a successful BPR implementation, being them definition of conceptual models for evaluating and implementing BPR and the implementation and assessment of BPR in all the enterprise departments (Roquete, 2018).

Regarding the definition of conceptual models, Maull points five key factors:

1. Strategic Approach.
2. Performance Measurement.
3. Define a business process architecture.
4. Consider both organizational and human components.
5. Define the role of IT.

After the implementation of BPR actions, the assessment must be performed considering the different dimensions within each factor.

2.3.4. Maturity Models Summary

As previously mentioned, the Maturity Models can be valuable assets for the organizations, since they enable companies to better measure their performance, to position in the market, making comparisons with their state and the best practices, and, also, the Maturity Models can support organizations on understanding what are the most profitable next steps to take.

Considering the maturity models studied in the literature review, it can be observed that there is a lot of documentation capable of supporting organizations in the implementation of Business Process Management.

The present investigation aims to propose a Maturity Model for the implementation of process automation within a company. Thus, the presented Business Process Management of MM should be considered in order to guarantee a solid basis to implement the automation.

Model	Purpose
Acatech MM	Evaluate the current state and guide the enterprise to the next step through the digital transformation journey.
Impuls	Assess organizations' ability to prepare for the digital transformation journey.
CMMI	Offer the best practices to orient companies in business processes' improvement. Assess performance and maturity of organizations' processes.
BPMMM	Measure the BPM maturity in an organization.
BPMM Fisher	Balance the ability to be easily related by everyone and the need of providing sufficient insights on specific actions for enterprises who strive to upgrade their processes.
BPMM-OMG	Assess the maturity of business activities regarding process management.
BPOMM	Understand the maturity of business process orientation within an organization through different areas.
PML	Introduce the habit of thinking about processes within the organization and its employees. Can be characterized by its celerity instead of performing a rigorous assessment.
PCM	Assess both the maturity of processes and the maturity of the organization in the BPM field evaluating its efficiency and effectiveness.
PEMM	Identify key factors in companies' performance improvement.
SAM	Overcome the often-known lack of connection between IT and the organization's strategy that often leads to inefficient and divergent results.
PMMA	Evaluate the implementation of BPM initiatives within the organization instead of focusing only in the assessment of the performance of a specific BP.
BPRMM	Orient organizations through process reengineering, i.e., implies a radical and revolutionary innovation and consequently involve structural changes in the organization.

Table 4 – MM Summary

For the reasons explained on the table above, Maturity Models that will be valued in the construction of this proposal are CMMI, BPMMM, BPMM Fisher, and SAM.

CMMI will be used since it is the classical support for process optimization, on the other hand, BPMMM is a reference on measuring and assessing the BPM position of an organization.

Additionally, BPMM Fisher is very valuable, since it provides insights on specific actions to take in order to move to the next stage.

Finally, SAM Model is important to consider, since it approaches the connection between Information Technologies and the overall organizational strategy.

3. METHODOLOGY

As it can be verified in the following sub-topic, Design Science Research, this methodology is appropriate to support the present study due to its nature. This is, the Design Science Research Methodology (DSRM) defends the importance of finding a problem within the subject under study as well as a motivation and relevance of the solution so that the investigation gains a purpose. As can be seen, these topics described here have already been addressed previously in this document.

In addition, the search for theoretical knowledge is stimulated, through the review of what already exists, in order to have a solid knowledge about the topic and its current environment. In this way, knowledge is obtained about how the artifact should be developed, as well as what it should incorporate and how it should fill the gap in question.

In order to give robustness and credibility to the research, the DSR recommends a demonstration and consequent evaluation of the usability and good functioning of the artifact, which, in this case, will be done through a use case and the participation of experts in this field.

It is important to highlight that the DSR states that the artifact must present a research contribution that must be palpable in terms of output.

In the present study, the artifact will take a form of a MM for Process Automation. One can verify that a MM fits the DSR artifact requirements since it can be considered a tool to help in the process automation journey, through taxonomies and well-defined metrics to position companies and organizations.

Additionally, DSR Methodology suits Information Systems' area and one can verify the usage of DSRM in similar studies (Roquete, 2018).

3.1. DESIGN SCIENCE RESEARCH

Design Science Research (DSR) can be defined as a methodology whose objective is to help create a suitable environment where the goals can be achieved and *things* can be work according to their purpose. Thus, DSR can be seen as a tool to change the reality into a more favourable situation (Geerts, 2011).

This approach is applied in various fields of technology, as DSR allows to identify organizational issues and boost innovation through the evaluation of IT artifacts (Bisandu, 2016).

In order to provide a better understanding on the DSR Methodology, Hevner (2004) has proposed guidelines which highlight the following considerations (Kaul, 2014):

1. The importance of design as an artifact, i.e., the output must be palpable, such as a technique or an instrument.
2. The need to evaluate the pertinency of the problem, in order to produce technology-based and problem-oriented solutions in compliance with the business needs.
3. The design should also be subject to a rigorous evaluation, in order to ensure the utility, efficacy and quality of the design artifact, through the use of robust methods.

4. The design-research should present clear and effective contributions for the areas of the design artifact, design foundations and design methodologies.
5. The construction and evaluation of the design artifact must be subject to a rigorous method.
6. The hunt for an effective artifact requires the consideration of the available factors/ instruments, in order to reach the aspired goals, as well as the satisfaction of laws within the environment of the problem.
7. The communication of the DSR must not only be oriented to technology but also to management needs.

In the figure below it can be seen an illustration of the DSR Methodology characteristic process.

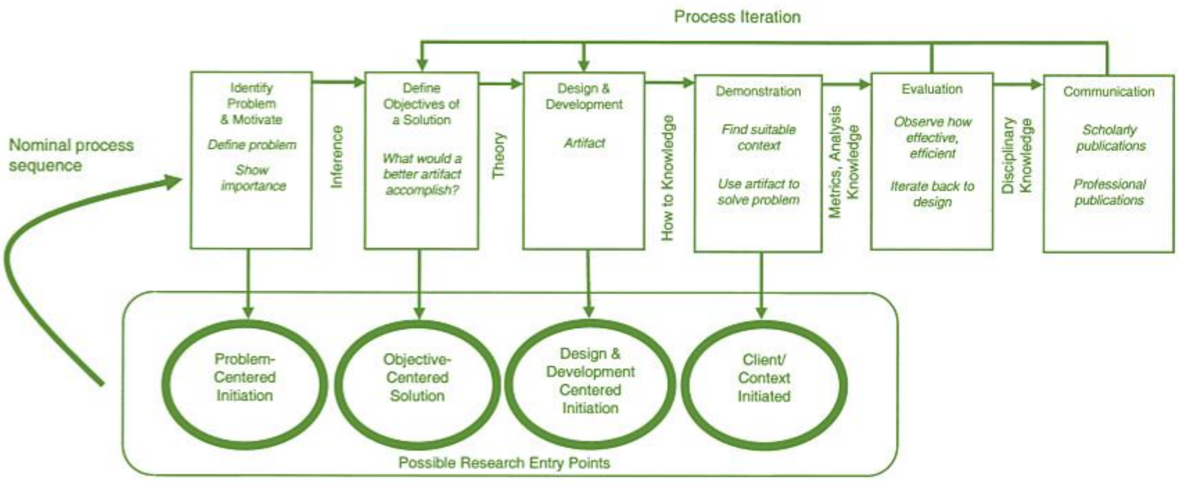

Fig. 17 – DSRM Process Model (Peffers et al., 2007)

As it is possible to verify, the DSRM it is composed of six large groups of steps:

1. Identify Problem and Motivate
   In this step, it is supposed to identify the problem to solve, as well as the value of reaching a solution. The result of the problem identification and definition will serve as the basis for the development of an artifact that could be the provider of the solution.

   By justifying the value of the solution, the researcher and the audience will be more motivated to achieve it, as well as to accept the solution output more easily. In addition, understanding the value of the solution allows the audience to better understand the researcher's reasoning.

2. Define Objectives of a Solution
   In this step, the researcher must identify the objectives of the solution, based on the identification and specification of the problem, as well as on the knowledge of the reality that surrounds the problem. This inference must be done through rational means and should consider knowledge about the state of the problem, existing solutions – if any – and the effectiveness of those solutions. Objectives may be qualitative or quantitative.

3. Design & Development

In this step, is where the artifact is created and developed. Artifacts are "any designed object in which a research contribution is embedded in the design" and, as already mentioned, artifacts should be palpable, as e.g., models and instruments.
In the 3rd step, the researcher determines the purpose of the artifact, as well as its architecture, before creating the artifact itself. In order to move on to development, it is necessary to gather theoretical knowledge to support the solution.

4. Demonstration
   The demonstration steps aim to prove the usage of the artifact to solve the defined problem or, at least, one instance of that problem. This phase can be conducted through experimentation, cases studies or other relevant and efficient manner.

5. Evaluation
   This step aims to compare the objectives of the solution with the results of the artifact demonstrated in step 4. In order to correctly perform the evaluation, it is crucial to have at hand knowledge of metrics relevant to the problem, as well as a solid ability to analyze the results, taking into account, once again, the problem identified.
   This evaluation can take any empirical evidence or logical proof, since it is considered appropriate for the scenario.
   Having performed this step, the researcher is in condition to evaluate whether the solution is working as expected or, in the other hand, the researcher can go back to step 3 in order to improve the effectiveness of the artifact

6. Communication
   This is the final step. Here is where the problem, and its relevance, is communicated and the novelty and usefulness of the artifact are announced, along with the rigour of the design.
   Additionally, it is important to highlight the concern on having disciplinary culture knowledge.

3.2. RESEARCH STRATEGY

Once the DSR is presented and its value motivated, the convenience of conducting this study based on this methodology can be verified.

Therefore, each of the characteristic steps of the DSR will be completed in this study:

1. Identify the Problem and Motivate: in the *Context* section, the problem – or gap – is presented and in both the *Motivation* and *Study Relevance and Importance* sections, the motivation to conduct this research and to find a suitable solution is justified.

2. Define Objectives of a Solution: in the *Literature Review* field, the state of the art of the problem is detailed, i.e., the environment of process automation technology is object of study, as well as their challenges and opportunities. Additionally, solutions (MM) for related topics are presented and their characteristics are identified. A pattern can be seen in these solutions and this pattern can serve as an inspiration for the present study output.

3. Design & Development: once the theoretical knowledge has been gathered and the existing solutions in the – wide – scope of the process automation theme have beenanalysed, the study can move on to the development part of what will be a Maturity Model. This MM aims to be a tool able to define different stages of maturity to classify and position enterprises in their processes automation journey, as well as help them to improve and move up to the next level of automation. Additionally, the output of this paper, the MM, also has the ambition to identify the impact of each automation addition in each field. This step can be seen in the P*roposal* section.

4. In the Demonstration phase, within the P*roposal* and, more specifically, in the Use Case sub-topic, a use case will be developed, in order to evidence the effectiveness of the artifact.

5. The evaluation is also conducted within the P*roposal* section, but now in the sub-topic *Evaluation & Discussion*. Here, the output of the artifact usage on the use case is compared with the goals – defined in step 2 – of the MM, i.e., the result that would be expected.

6. Also, within the scope of *Evaluation & Discussion*, the solution is communicated with all the specificity of its novelty, usefulness and development rigor.

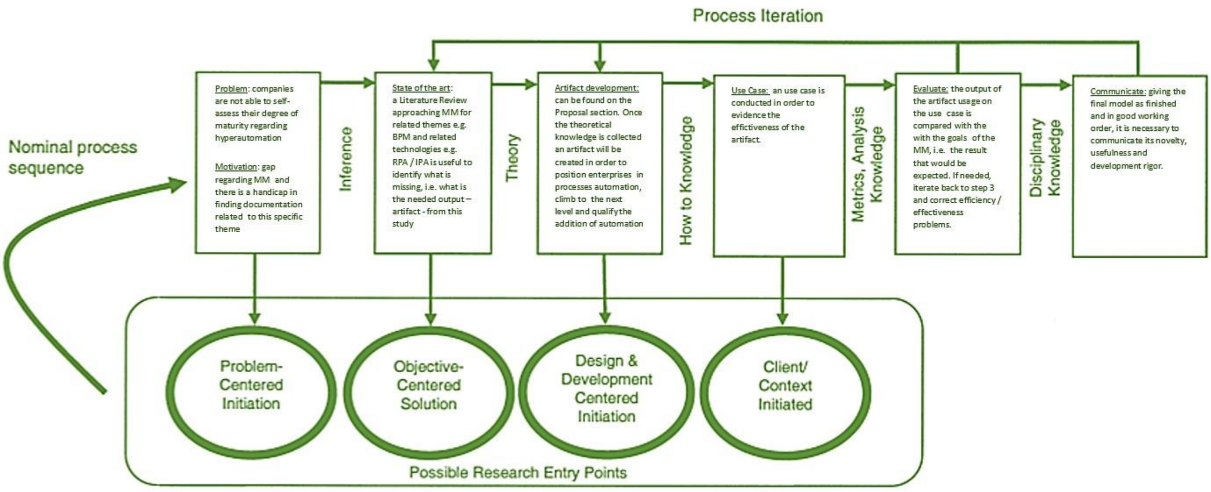

Fig. 18 – DSRM Process Model of a Process Automation MM (adapted from Peffers et al., 2007)

In order to develop the present study, in compliance with the DSRM, it is crucial to carefully address the six characteristic phases of this methodology.

This way, it is necessary to research regarding the *Context* – a section of this paper – of the theme, in order to gain perspective on the trends within the topic and realize the gaps that exist, i.e., the problem. Also, it is fundamental to give a purpose for the investigation, that is why the *Motivation* section shows the benefit of having MM to guide journeys, namely, technological journeys. Here are mentioned areas where MM exist: e.g., BPM and Industry 4.0 and the question of why it does not exist for hyperautomation begins to arise. The motivation for this work is found.

A deep reading of the literature, *Literature Review*, and an understanding of similar studies, carried out on comparable areas, will be required. This way, the concepts regarding process optimization and process automation were studied and documented. The same exercise was carried out for technology that make up or are at the basis of the ones that make up hyperautomation. The concepts within process automation needed to be explored as well as the areas – e.g., Finance or Industry –, the challenges and opportunities inherent to hyperautomation and the technological approaches – e.g., RPA, IPA. Besides the process automation, the field of Maturity Model also needed to be object of study, namely regarding the concepts, the Capability Maturity Model Integration (CMMI), the state of the art of BPM Maturity Models and a summary of the studied MM.

Similar to the existing Maturity Models for other areas, it will be necessary to define, in the *Proposal*, appropriate taxonomies for the five levels of the artifact in question. Additionally, quantifiable, and clear metrics must be defined to assess each of the MM levels. Thus, the metrics must be based on characteristics to which it is possible to apply a pragmatic and measurable perspective, for this, the descriptions of each level – taxonomies – must avoid subjectivity.

The output of the present study should be a MM – taxonomy – proposal, able to position and guide companies through the process automation journey and help in their moving to further levels. It should be noted that another feature expected for final artifact is to have the power to help organizations understanding the impact of adding automation, i.e., the impact of levelling up in MM, taking into account the characteristics of the organization in question.

Experts in the area will validate the output and a use case will be conducted, in order to demonstrate and evaluate the effectiveness and efficiency of the solution. As the best practices point, in the final stage of this paper the communication of the artifact usability and development will be presented and must include limitations and future work.

4. RESULTS AND DISCUSSION

This section is characterized by the presentation of the final proposal of the present paper. Thus, it is possible to expect, in addition to the MM proposal, a contextualization of the levels that compose it, as well as the presentation of methods of use – through an use case – and, finally, the evaluation and discussion of the proposal.

4.1. Assumptions

Considering the Literature Review carried out to develop this investigation, the main competences that matter in the automation journey were raised.

As previously mentioned, there is a gap regarding Maturity Models in the area of hyperautomation and, this way, the Maturity Models studied will serve as the basis for the Model that will be proposed in this dissertation.

In addition to the presented Maturity Models, the proposed MM will take into consideration the different technologies referred to throughout the document, as well as their level of evolution, in order to be part of an automation solution.

Thus, a solid BPM implementation is valued, since it is the basis of the well-functioning of the processes' articulation in an organization and, without the root, it is not possible to build the roof.

Besides the component of processes optimization – through BPM –, it is important to guarantee a strong path to succeed in the automation implementation.

As previously observed in the present study, several Maturity Models highlight the importance of the organizational culture and people, since the employees are those who, ultimately, have the power to shape an organization through the work they do every day and the pride they bring to it. For this reason, the proposed Maturity Model will stand on three great pillars:

- People & Culture.
- Processes.
- Technology.

In order to support the necessary structuring of the three components listed above, within the scope of each maturity level, the following models were considered:

- CMMI – to support the Processes component.
- SAM – to support the Technology component.
- BPMM Fisher – to support the People & Culture, Processes and Technology components.
- PBMMM – to support the People & Culture, Processes and Technology components.

4.2. Model

The proposed Maturity Model aims to guide the process of implementing process automation and optimization from its simplest form to the complexity characterized by hyperatomation, where intelligent robots assess and judge the situations while communicating with each other, automating end-to-end processes.

Since it is important to take into consideration the appropriate automation for each reality, the proposed model includes an identification and respective description of the steps and technology necessary to achieve a certain predefined objective. Thus, the model is adjustable to different dynamics and can fit in different Organizations.

This Maturity Model is composed by five levels:

1. Manual: absence of automation and optimization, characterized by essentially manual processual flows.
2. Initial: there is some maturity in process optimization and – initial – interprocess communication.
3. Repeatable: the processes are formally defined, as well as their flow, this level already includes automation based on simple and repetitive rules.
4. Intelligent: at this stage, the organization already has intelligent robots that can perform tasks requiring judgment, i.e., that are not necessarily based on simple and repetitive rules.
5. Hyperintelligent: this level is characterized by the hyperintelligence of connecting robots which, in themselves, are intelligent, and thus allowing for an end-to-end process automation.

The simplified flowchart below can summarize this Maturity Model levels and, following the chart, there is a more detailed explanation on each stage.

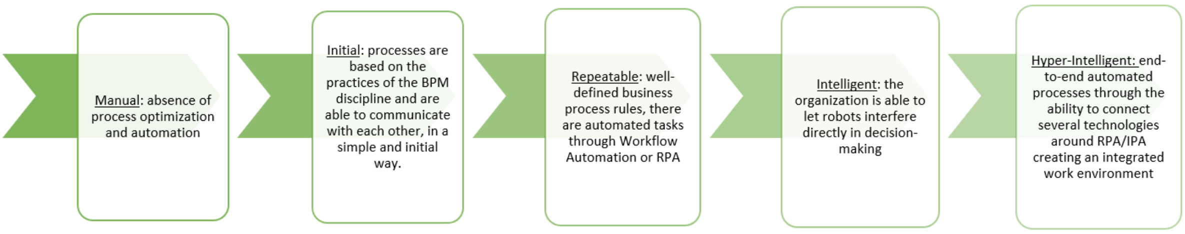

Fig. 19 – Simplified version of the proposed MM

Level 1: Manual

The level 1 of the proposed MM aims to characterize the absence of process optimization and automation.

At this stage, processes are not properly defined, which makes them ineffective and inefficient. Additionally, at level zero, there are no automation, but processes where interactions take place via humans. It should be noted that since the processes are not defined, the addition of automation would not be desirable, considering that the absence of process optimization means a lack of maturity for automation. To move to the next level, the organization must first give in to the inherent requirements of BPM.

According to CMMI, organizations in this level should model, formally define, and improve existing processes locally, i.e., per department.

BPMM Fisher suggests the adoption of standards and governance methodologies, as well as the implementation of value measurement, this model also advises to bet on good communication between departments and poles. BPMM Fisher also reiterates that, in order to move to the next level, organizations need to define Change Management procedures and should not look at the work of each employee or team in isolation. It is common that at this level the systems and the little automation that exists are not interconnected, and it is important to improve this point to make the processes more mature.

Level 2: Initial

The 2nd level of the proposed MM characterizes the stage of Organizations whose processes are based on the practices of the BPM discipline and in which they can communicate with each other, in a simple and initial way.

Thus, this stage presupposes the existence of a Business Process Management System (BPMS), in order to be enable the monitoring and improvement of processes, namely, when several instances of the same processes are running simultaneously. It is important to mention that this technology allows to orchestrate the communication between the different agents of the processes, i.e., machines, systems, or human employees, so that it is possible to increase the integration of the processes.

Making use of the study previously performed, regarding Maturity Models, it can be said that according to CMMI, Organizations at this 2nd level are positioned on the 2nd or 3rd level, i.e., processes are defined at least at a local level and to move to the next level, Organizations must measure their performance through defined metrics.

Taking into consideration BPMM Fisher, the IT component is situated at the "Process Driven" level, as it implies that the operation is process focused across the enterprise. Still regarding BPMM Fisher, the Processes component must be, at minimum, between the level of “Tactically Integrated” and “Process Driven”, i.e., processes must be based on the Organization's IS and there must be a culture of focus on processes. Regarding peoples’ component, it is positioned in the “Tactically Integrated” stage, once it supposes the existence of cross-functional processes, but a limited understanding of cross-departmental processes needs.

In enterprises, at this stage, the processes are well-defined and there is a repository of processes.

Level 3: Repeatable

The "Repeatable" level assumes that the Organization already has a BPM plan in place, i.e., that the organization is already oriented towards processes as well as their respective optimization.

Having well-defined business process rules, organization can start to automate tasks throughRobotic Process Automation (RPA).

RPA is a software that operates inside machines, as if it were a robot, i.e., it operates in the GUI, taking into account basic rules – if then – to perform tasks that have already been optimized via BPM. Thus, RPA should be implemented to perform tasks that do not need judgement, that are repeatable, sequential, and easily documented through rules. This software is able to receive structured data and treat it faster, with less errors and at a lower cost than humans do.

According to the Maturity Models Literature Review, namely CMMI, Organizations at the Repeatable stage – 2nd level – are on the 4th position of CMMI – Quantitively Managed – where performance metrics are frequently used to monitor processes. Here, organizations can start looking for continuous process evolution and improvement.

Taking into consideration BPMM Fisher, the IT component is situated on the "Intelligent Operating Network" level, as it implies that PBM practices are in place to automate and monitor the processes' execution, as well as an implementation of Automation, at least at a local level. The Processes component should be, at minimum, in the "Process Driven" level, i.e., the organization has its focus on business processes, as well as in their measurement through defined evaluation metrics. The peoples´ strand must be on the 3rd level – "Process Driven" –, i.e., there are process leaders in charge of the process maintenance and improvement and the functional teams can be focused on high quality deliveries.

In order to move to the next level, it is profitable for organizations at this stage to put into practice process analytics techniques, not only to analyse the processes but also to simulate "what if" scenarios, so that the process is optimized to maximum before taking actions to move to the next level. The process analytics techniques include a monitoring of the processes where data is extracted, in order to be analysed and provide insights on the processes' state of the art.

Additionally, a process auditing could also support the strengthening of procedural flows. This audit can either be done internally or externally, but the goal is to identify process issues and emit recommendations of improvement. Depending on the existing documentation, this audit can be performed through a sample of process data or – preferably – Process Mining techniques can be put into practice, retrieving event logs from the process activity instances, using directly the data recorded in the information system, to achieve a complete scenario of the process behavior as well as improvement opportunities.

Organizations at the 3rd level are prepared to perform the integration of the existing automation.

Level 4: Intelligent

The 4th level of the proposed MM expects that the organization already automates simple and repetitive tasks – RPA.

More than simple automated tasks, this level presupposes that the organization is able to let robots interfere directly in decision-making, which are intelligent – Intelligent Process Automation (IPA). Through the addition of Artificial Intelligence (AI), companies in the "Intelligent" stage have software that can do analytics on data from different sources, in a structured and unstructured way, as well as coordinate the different robots.

According to the Literature Review of Maturity Models, considering the CMMI, Organizations on the 3rd level of the MM are on the 5th stand of CMMI – Optimized, where there is a continuous improvement of processes. Taking into account BPMM Fisher, in the Processes component, organizations at this level are positioned in the “Optimized Enterprise” stage, since it is characterized by an integration of automation across the company, as well as a continuous optimization of processes. The component aimed at employees – People – must be at a maturity of “Optimized Enterprise”, which means that there are learning initiatives within the scope of business processes for employees, and they are committed to optimizing those processes.

Similarly to what was recommended in the previous step, organizations at this level must also put into practice analytical methodologies to obtain insights into the functioning of the process or even to make simulations of changes to the process in order to make it more efficient.

Additionally, process auditing is also applicable to organizations at the Intelligent level, to understand deficiencies in the process flow before catapulting to the next maturity level.

It is important to highlight that organizations at this stage are focused on continuing to improve the efficiency, effectiveness and solidity of processes and their integration.

Level 5: HyperIntelligent

Considering the Hyperintelligent level of the proposed MM, one can affirm that organizations at this stage already use intelligent bots to automate processes, meaning that not only the simple and routine tasks are in scope.

More than intelligent robots to automate more complex tasks, the present level represents the capacity to integrate those tasks, i.e., promoting end-to-end automated processes through the ability to connect several technologies around RPA/ IPA, creating an integrated work environment.

Similar with what happens in the previous stage of this proposed MM, level 5 of the CMMI should be reached.

Taking into account BPMM Fisher, in the Processes strand, organizations at this stage position on the “Intelligent Operating Network” degree once it is characterized by the total process integration across the ecosystem of the company. Similarly, the People component must also be positioned at the higher level, i.e., the culture for process optimization is valued within the organization and training initiatives in the area of processes’ optimization for employees are constantly being updated.

Although organizations at this level have reached the highest level of maturity of this model, it is always necessary to maintain an effective monitoring of the processes. Thus, it is important that process analytics techniques remain active in the company so that insights continue to be known. In addition, it is important that recurring audits are carried out on the processes,, in order to understand that they continue to operate in the desired way and that they follow the expected procedural flow.

Nevertheless, auditing, even in organizations at the Hyperintelligent level, can serve to make recommendations for updating or improving processes.

Maturity Levels Position and Recommendations

The table below combines some of the previously studied models crossing its components in order to characterize the levels of the proposed model in the fields of People and Culture of the organization, as well as in the scope of Processes and Automation.

Thus, to characterize the component of People and Culture, BPMMM and BPMM Fisher were used as a basis. To define the levels of the Processes, CMMI model, BPMMM, BPMM Fisher, BPMM-OMG, PML, PCM and PMMA were taken into account. For the characterization of the Automation, PBMMM, BPMM Fisher and SAM models were used.

	People & Culture	Processes	Automation
Level 1 Manual	BPMMM 1; BPMM Fisher 1	CMMI 1; BPMMM 1; BPMM Fisher 1/2	BPMMM 1; BPMM Fisher 1/2; SAM 1/2
Level 2 Initial	BPMMM 2; BPMM Fisher 2	CMMI 2/3; BPMMM 2; BPMM Fisher 1/2	BPMMM 2; BPMM Fisher 3; SAM 3
Level 3 Repeatable	BPMMM 3; BPMM Fisher 3	CMMI 4; BPMMM 3; BPMM Fisher 3	BPMMM 3; BPMM Fisher 4; SAM 4
Level 4 Intelligent	BPMMM 4; BPMM Fisher 4	CMMI 5; BPMMM 4; BPMM Fisher 4	BPMMM 4; BPMM Fisher 5; SAM 5
Level 5 Hyper-Intelligent	BPMMM 5; BPMM Fisher 5	CMMI 5; BPMMM 5; BPMM Fisher 5	BPMMM 5; BPMM Fisher 5; SAM 5

Table 5 – Sources for the proposed MM

For a better understanding of the proposed MM, the table below provides the detail of each level for each component as well as the actions needed to move for the next stage:

	People & Culture	Processes	Automation	Needs
Level 1 Manual	Individual work and lack of communication within the organization.	Processes are not formally defined and there is no articulation between them	No automation of processes	• Define and improve existing processes • Model and formalize existing processes • Make use of Governance Methodologies • Improve the communication both within employees and processes • Counteract the isolation of existing systems and automation
Level 2 Initial	There are standards defined to align the work of different business units but there is still existing a lack on uderstanding of cross-departmental processes needs	Processes are based on practices of the BPM discipline and are able to communicate with each other, in a simple and initial way, i.e., processes are defined at least at a local level	Existence of a BPMS in order to enable the monitoring and improvement of processes	• Measure the performance through defined metrics • Describe the rules for basic tasks – if then else • Automate basic and well-defined tasks • Implement the practice of defining process leaders who have the functions of improving and maintaining core processes.
Level 3 Repeatable	There is connection between departments and there are process leaders in charge of the process maintenance and improvement	Performance metrics are fequently used to monitor porcesses and the organization has its focus on business processes	Workflow Automation or RPA – Robotic Process Automation to enable the automation of simple and repetitive tasks	• Integrate the existing RPAs • Add artificial intelligent to bots in order to allow them to judge • Continuously monitor processes so they can improve • Foster training initiatives for employees within the scope of business processes • Implement Process Analytics and Process Auditing / Process Mining techniques
Level 4 Intelligent	There are learning activities in place in order to encourage employees to be committed to processes´optimization	The organization focus is on continuing improvement of the efficiency, effectiveness and solidity of processes and on the integration of the existing automation	IPA - software that can do analytics on data from different sources, in a structured and unstructured way, as well as coordinate the different robots.	• Automate end-to-end processes • Automate processes and implement seamless communication between them • Foster the participation of leaders and employees in the search for increasingly optimized processes • Keep performing Process Analytics and Process Auditing / Process Mining techniques
Level 5 Hyper-Intelligent	Everyone in the organization is seeking for gaps/bottlenecks in the processes, to improve them and the training initiatives are constantly being updated	Integral process integration accross the ecosystem of the company	Hyper-Automation: promoting end-to-end automated processes through the ability to connect several technologies around RPA/IPA creating an integrated work environment	• Keep the monitoring of the processes' performance • Keep evaluating gaps and bottlenecks • Update the environment when changes occour • Keep trainning employees with the best practices • Keep performing Process Analytics and Process Auditing / Process Mining techniques

table 6- Detail of the maturity levels of the proposed MM

In addition to the presented tables, it is profitable to provide a simple flowchart exemplifying how to apply the assessment suggested by the described Maturity Model:

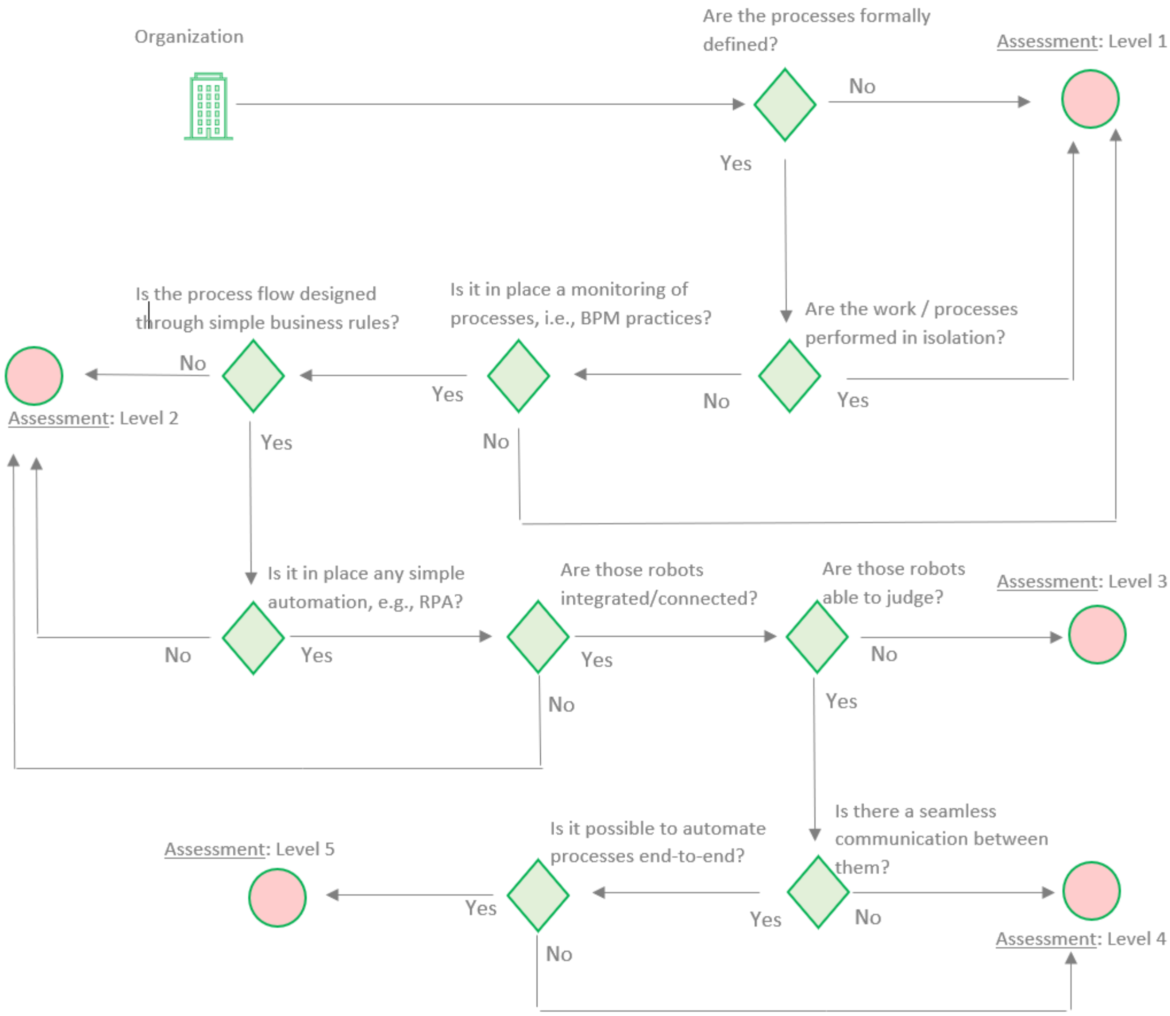

Fig. 20 – Flowchart to classify Maturity Levels

Automatic Maturity Level Classification

Additionally, the classification of the Maturity Level is suitable to be performed through a predictive algorithm. For that purpose, it was used a K Nearest Neighbors (KNN) Algorithm to allow the classification of the MM.

Thus, a fictitious dataset with 100 occurrences was built in order to serve as the model input. Below, it is possible to find the attributes and their meaning:

Attribute	Description
Defined Processes	Processes are formally defined at least at a local level.
Governance	Standards defined to align the work of different business units
Processes' Communication	The processes are designed to work together.
Isolated Systems	There is a possibility for existing systems to communicate with each other.
Performance Metrics	The company retrieves metrics from the processes, e.g., the execution success or time.
Rules defined	The processes are designed through well-defined rules.
Automated tasks	There are automated tasks within the company.
Process Leaders	There are employess in charge for the processes' management.
RPAs	There are tasks executed by RPAs within the company.
AI	The company makes use of Artificial Intelligence regarding processes.
Processes monitoring	Processes' executions are monitored.
Training for Employees	There are in place actions to improve employees´ awareness to process optimization and execution.
Process Analytics	The company retrieves analytical data from processes execution through the analysis of process instances.
Process Mining	The company extracts event logs directly from the systems' data bases.
Process Audit	The process worflow is periodically examined to unerstand if everything is in compliance with the supposed functioning.
End-to-end Automation	There are processes which are end-to-end automated, i.e., can be entirely performed by machines.
Seamless communication	More than process communication between departments, i.e., the processes can communicate through all the company.
Gap Analysis	It is implemented the practice of search for bottlenecks and gaps on existing processes.
Adaptative Environment	The structure is built in a way that it is possible to easily adapt the working if changes are needed.
Classification	Final classification, i.e., Maturity Level on process automation.

Table 7 – KNN input features

It is important to highlight that after a correlations check, seven attributes were deleted due to high correlations, being the threshold a correlation equal or higher than 0.8, which increases the model redundancy and can promote an overfitted model.

After this removal, the dataset had the following columns:

1. Governance
2. Isolated Systems
3. Performance Metrics
4. Rules Defined
5. Process Leaders
6. AI
7. Training for Employees
8. Process Audit
9. End-to-end Automation
10. Seamless Communication
11. Gap Analysis
12. Adaptative Environment
13. Classification (Target)

Thus, the "Classification" feature was defined as *y* – dependent variable – and the remaining ones as *X* – independent variables.

From those 100 occurrences, 80 were used for the training set – where the model learns the behavior inherent to each of the stages – and the remaining 20 were used in the test set.

It is important to highlight that in the case of this dataset, there was no need to perform data standardization, since all the variables were converted to binary features, i.e., 1 or 0 (meaning "Yes" or "No").

Below, it is possible to observe the result obtained after running the model:

TRAIN

	precision	recall	f1-score	support
1	0.90	1.00	0.95	18
2	0.83	0.88	0.86	17
3	1.00	0.73	0.85	15
4	0.92	1.00	0.96	12
5	1.00	1.00	1.00	18
accuracy			0.93	80
macro avg	0.93	0.92	0.92	80
weighted avg	0.93	0.93	0.92	80

VALIDATION

	precision	recall	f1-score	support
1	1.00	1.00	1.00	4
2	0.75	1.00	0.86	3
3	1.00	0.67	0.80	3
4	1.00	1.00	1.00	5
5	1.00	1.00	1.00	5
accuracy			0.95	20
macro avg	0.95	0.93	0.93	20
weighted avg	0.96	0.95	0.95	20

Fig. 21 – KNN accuracy metrics on classification of Maturity Levels

Interpreting the obtained results, one can understand that the model mismatches the most the class corresponding to the 2nd level of the Maturity Level, i.e., from all the occurrences predicted as being part of this class, 0.83 and 0.75 were correct, considering the train and validation sets.

Regarding the recall metric, it is possible to understand that the worst predictions correspond to the 3rd Maturity Level, i.e., from all the instances that belong to this level, the model identified correctly 0.73 and 0.67 in the validation and test sets, respectively.

However, even considering the worst results of the model, both the accuracy and f1-score show that the model performance is good.

4.3. USE CASE

The present section of the dissertation aims to demonstrate how the proposed Maturity Model can be used to position an organization in the field of automation and, additionally, how to catapult the enterprise to the next level.

The organization that will be used for this exercise is a medium size health company dedicated to the treatment of patients with respiratory diseases. This business is based on the supply of gases, e.g., oxygen, as well as machines that help in the treatment of respiratory diseases, such as sleep apnea. Thus, this company, in addition to gases and machines, has specialized health technicians who provide this service at home in the different regions of our country, which are divided into North, Center and South.

Nowadays, all the technicians have a Personal Digital Assistant (PDA) that can be described as small-sized computers with a large computational capacity, fulfilling the functions of an organizer and elementary office computer system, with the possibility of interconnection with a personal computer and a wireless computer network. The employees use these devices to notify, in the organization's system, when a service is completed, in order to make this information available for the management and also for their colleagues. Additionally, PDAs also serve as agendas, this way, the management can provide in the system the weekly/ daily schedule of a technician indicating the patients, the timings, the needs of each patient and other relevant details, so that the technician can immediately know where to go and thus make communication more simplified.

With the information that is taken from the system, where the technicians submit details about when services are started and finished or details about the patient's needs, the company's administrative area is responsible to – manually – reschedule the technician's next visit to a specific patient, count the time spent in each patient, taking into account the schedule that the technician has placed in the system, check if there is a route that the technician can adopt that is more efficient, taking into account the location of the respective patients, validate the stock of gases and machines to order from the supplier, among other tasks.

In this way, this company can be evaluated as level 2 – Initial, using the Flowchart previously presented:

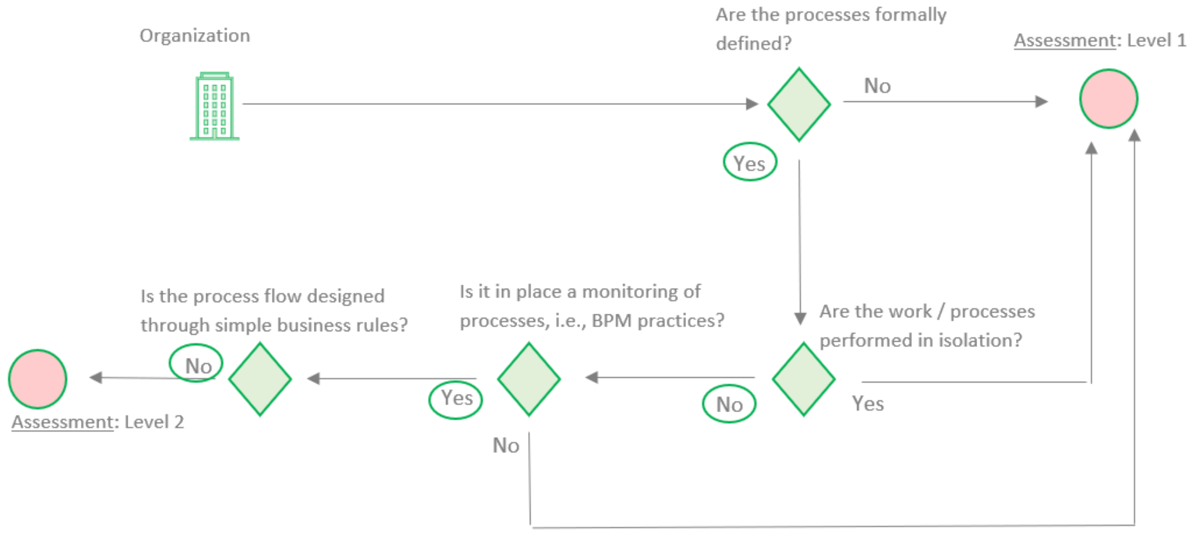

Fig. 22 – Use-Case flowchart

Taking into consideration the tables presented with the three components – People & Culture, Processes and Automation – and the steps to move to the next level, this organization can improve in the following lines:

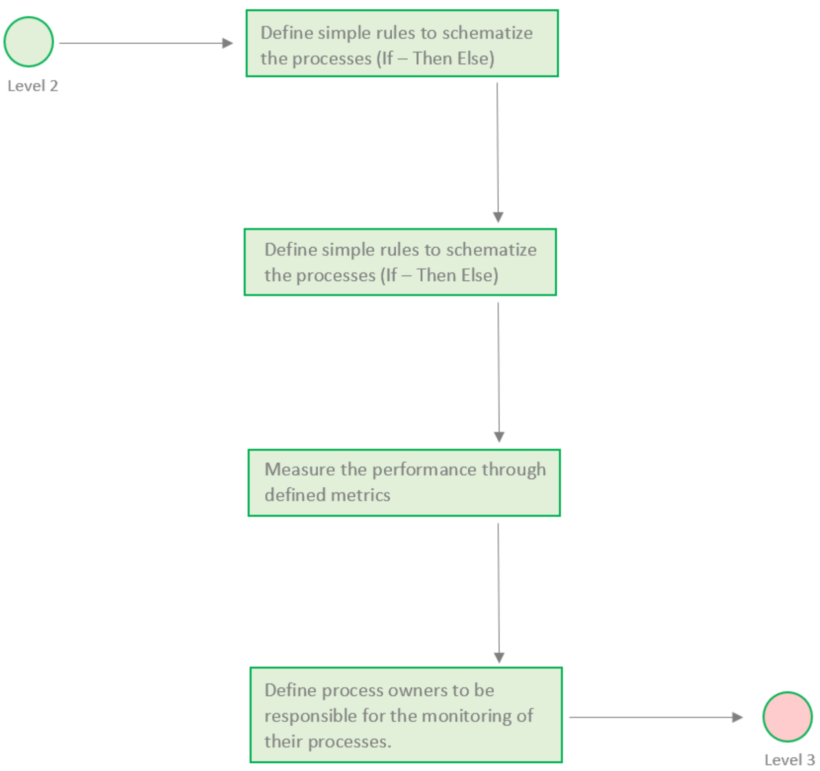

Fig. 23 – Use-Case needs

Following these steps, the organization will be able to lighten administrative work, making it more efficient and spending less time.

Automatic Maturity Level Classification example

However, assessingmaturity levels through a flowchart can be a very limited option, because even if an organization presents a good level of development in a given topic, if any of the requirements is not fully covered, the assigned level will always be below of what would be reality.

For example, referring to the 2nd level of maturity of the proposed model, it is plausible that a company has the processes able to communicate properly between the same department and that BMPS are implemented, however, despite that organization is using BPM techniques, it is still without a formal process monitoring. Thus, this organization, through a flowchart would be considered level 1, while its effective development belongs to the 2nd level (although it may be recommended that formal governance policies be defined).

In order to better illustrate this situation, the KNN model presented in the previous section can be used. As such, keeping to the example of the healthcare company, it is possible to verify that companies with different characteristics can also be classified in the second maturity level, since, despite having differences between them, they all gather the fundamentals of this class.

Thus, through the piece of code and respective outputs provided below, it is possible to verify that both instances are classified with the 2nd level of maturity and, in one of them (corresponding to our example of the healthcare company), the processes are monitored, but the other instance processes are still not being monitored. As such, it is possible for instances with different characteristics to be included in the same basket and thus, better represent the real world.

```
df.iloc[24:25, :-1]
```

	Defined Processes	Governance	Processes' Comunication	Isolated Systems	Performance Metrics	Rules defined	Automated tasks	Process Leaders	RPAs	AI	Processes monitoring	Training for Employees	Process Analytics	Process Mining	Proce Auc
24	1	1	1	1	0	0	0	0	0	0	1	0	0	0	

```
df.iloc[89:90, :-1]
```

	Defined Processes	Governance	Processes' Comunication	Isolated Systems	Performance Metrics	Rules defined	Automated tasks	Process Leaders	RPAs	AI	Processes monitoring	Training for Employees	Process Analytics	Process Mining	Proce Auc
89	1	1	1	1	0	0	0	0	0	0	0	0	0	0	

Fig. 24 – Use-Case KNN input

Use Case

```
## Use Case Instance
UseCase_1 = df.iloc[24:25, :-1]
```

```
UseCase_2 = df.iloc[89:90, :-1]
```

```
MaturityModel_1 = classifier.predict(UseCase_1)
MaturityModel_2 = classifier.predict(UseCase_2)
```

```
MaturityModel_1
```

```
array([2], dtype=int64)
```

```
MaturityModel_2
```

```
array([2], dtype=int64)
```

Fig. 25 – Use-Case KNN output/ classification

4.4. Evaluation & Discussion

Following, it is possible to find the evaluation and discussion of the proposal of this paper, which had the judgement of experts in the areas that contextualize the proposed Maturity Model. Additionally, also within this section, the development of a suggestion for improvement provided by the experts can be observed.

4.4.1. Validation Scope

In order to assess the suitability of the maturity model proposed in this study, as well as to give it credibility, the following section is based on a validation exercise.

This way, a validation interview was carried out to three experts on the field of processes and analytics, two of whom belong to academia and the third represents the industry. More specifically, the first expert (E1) is a professor in the area of process management, the second expert (E2) is a professor in the area of machine learning and the third expert (E3) is a Power Platform Support Engineer specialized in Power Automate and Power Virtual Agents tools (RPA, Automation and bots) at Microsoft.

4.4.2. Validation Interview & Respective Answers

Following, it is possible to find the questionnaire that guided the interviews carried out with the experts, including the answers provided by them, in order to ensure the reliability of the Maturity Model proposed in this dissertation.

Question 1 – Since none of the current models can be used for the implementation of automation, do you think it is useful to create a new Maturity Model that allows guiding the path of processes' automation of an organization?	
E1	Yes, because it complements what already exists and demonstrates a useful perspective that adds to what already exists in academia. Processes in companies have been growing and end up becoming quite complex, also due to the input of technology that is involved in the daily life of companies and may accentuate the difficulties for some organizations to position themselves and advance in this area, so that makes this study even more useful for academia. In summary, this dissertation is a contribution that adds value to the process automation environment.
E2	Yes, nowadays there are several problems in organizations, in terms of process transformation. Thus, a lack of skills that is difficult to combat, namely because it is difficult to position and understand in what stage a certain organization is located. This way, having a framework that can guide this process is an added value, making the transition to higher levels simpler and more objective considering the processes and automation topic.
E3	Yes, it is useful. This model does not represent restricted conditions, which is a benefit. So, at this point, it is possible to adapt the model to realities of different companies with different environments. For example, there are companies with, more or less, structured processes that may end up, in fact, having a similar maturity and the present model allows that.

Table 8 – Expert's answers to the first question

Question 2 – What is your opinion on the suitability of the proposed Maturity Model?	
E1	A Maturity Model is always an important way to understand where a certain company is, and can have more or less levels, depending on having more or less criteria. I believe the five levels make sense because it is an odd number, so that allows for some hierarchy, since it has a well-defined middle. The proposed Maturity Model is a gain in terms of the perception of process maturity as well as in understanding whether the company is positioned for the automation journey and, if so, to what extent. In Portugal we have a business fabric based very much on Small and Medium Enterprises (SMEs), most of which will not model their own processes. Many companies will only design their flows in the form of an organizational chart (in the 1990s, with the development of the Information Systems, it was defined in the quality standards as a must have). However, organizations and their culture often have insufficient awareness to reach further steps and from there it makes sense to include the "people and culture" pillar. That is, it often happens that companies are aware of the processes but are not aware of their position through the journey of process automation and optimization. To conclude, I believe the levels have a logical sequence, which makes sense for me.
E2	There are two aspects that are important to highlight, in my point of view. Taking into account the five levels of this model, if we are going to use a flowchart to assess the level of maturity and automation of an organization's processes, we will be having a very limited and restricted approach with very well defined, schematized and formalized rules. There are companies with different characteristics, whether in process organization or in training professionals, for example, that, through a flowchart, can position themselves at different levels, but that, in reality, they are not that different in terms of maturity of process automation. Thus, using another method, more advanced and with ML techniques, such as a KNN (or something more complex, eventually, in a future work), we could reach a result closer to the truth, bringing a more significant contribution.

E3	Yes, I believe this Maturity Model is possible to be implemented. However, the success or failure of the MM ultimately depends on who is applying it. For example, an organization that is not properly structured may not be able to follow each step due to not finding the necessary data. In other words, I believe companies must have some structure to be able to follow the model.

Table 9 – Expert's answers to the second question

Question 3 – What improvement recommendations do you propose to enrich the proposed model?	
E1	My recommendation is to streamline the model in the face of a case, that is, to interview a company that can somehow assess the suitability and feasibility of the model. In order to achieve this, it would be interesting to use the "needs" component of the "Detail of the maturity levels of the proposed MM" table to understand the interviewee's reaction, since it is important to be aware of possible obstacles, such as, e.g., lack of staff, lack of budget and so on.
E2	I recommend that the flowchart is not used since it would be very difficult to frame this process in something that is constituted by rules as strict as a flowchart. This is a type of situation in which Machine Learning is very useful because for the human being it is sometimes difficult to make this type of evaluation objectively. Therefore, I recommend investing more in ML techniques for this type of problem, as they can identify the most important characteristics in an organization that can be used for predictive models, to identify an organization's positioning on this journey. In short, I recommend ML-associated models in contrast to flowcharts or other constrained techniques. Finally, it is interesting that there are five levels of maturity, but I consider it difficult for any organization to reach level 5, which is equivalent to having an Artificial Intelligence level equal to three, in which human intervention is completely irrelevant and in which we have an Artificial Intelligence that is capable of learn alone, which is very hard to achieve.
E3	I believe the only thing I would recommend would be to make it clear that it is needed to define a set of requirements for companies to be able to follow the model. For example, in my point of view, before applying the model, a company should be aware about which processes are known a priori to communicate with each other. That is, to have the minimum knowledge, in order to be able to implement the model recommendations successfully.

Table – 10 Expert's answers to the third question

Briefly, the experts' answers can be summarized in the following table:

Answers Summary	
Question 1	Yes, this study is a contribution that adds value to the process automation environment.
	Yes, this model can help in overcoming several problems in organizations, in terms of process transformation.
	Yes, it is useful, does not represent restricted conditions.
Question 2	Yes, and having five levels is beneficial, since it allows for some hierarchy. Also, I believe these levels have a logical sequence.
	Yes, but the assessment must be done through the KNN (or other ML technique).

	Yes, but the ultimately depends on who is applying it.
Question 3	To prove its suitability, one must streamline the model in the face of a real case.
	Besides the recommendation of using only ML instead of flowcharts, the E2 left the note that he believes the 5^{th} level is very hard to reach.
	The companies must be somehow structured before implementing the model.

Table 11 – Expert's answers summary

Considering the answers given by the experts, the three agree that the maturity model proposed here contributes an added value to what currently exists in the area of process optimization and intelligent automation. Additionally, it was mentioned that the maturity levels are conveniently defined and structured.

It is important to highlight that E3 suggested that, in the presentation of this Maturity Model, it is necessary to make it clear that the success of its implementation, ultimately, depends on the company/ person in charge for implementing it. Additionally, she also suggested that companies, before adopting the proposed model, should already have some awareness and structuring, at least, at the level of business processes.

It is also important to reflect that E2 stressed that, in its opinion, the model should only consider the KNN to carry out the positioning of the companies, since flowcharts are too restricted to assess this reality.

Regarding the recommendation provided by E1, it was suggested to, in order to prove the usability and usefulness of the proposed model, perform an interview directed to a company in order to understand the real challenges of implementing the model as well as if it is considered viable.

4.4.3. Development of the Suggested Improvement

Once the E1 recommended an interview directed to someone in a company, to assess the suitability of the proposed Maturity Model implementation, a questionnaire was carried out to the general director of a health care company in Portugal.

In order to contextualize the reader, this company provides health care under the aegis of a multinational, so, the interviewee is the responsible for Human Resources and daily operations in Portuguese territory.

As suggested by the E1, to guide the survey, the "Needs" column of the "Detail of the maturity levels of the proposed MM" table was used to understand if the proposed steps are suitable.

To begin with, I consider it pertinent to frame that the KNN model was used to position this company and, taking into account that same position, the respective "Needs" were used to conduct the interview. Below is the occurrence relative to this company – already containing only the features relevant for the model – and the level assigned by the KNN (4), for reference only, followed by the questions presented and respective answers.

```
In [29]:  1 Predict
Out[29]:
```

	Governance	Isolated Systems	Performance Metrics	Rules defined	Process Leaders	AI	Training for Employees	Process Audit	End-to-end Automation	Seamless communication	Gap Analysis	Adaptative Environment
1	1	0	1	1	1	0	1	1	0	0	1	0

```
In [33]:  1 MLevel = classifier.predict(Predict)

In [31]:  1 MLevel
Out[31]: array([4], dtype=int64)
```

Fig. 26 – KNN output/ classification for the interviewed company

Question 1 – **Do you consider it is possible for the company to embark on end-to-end automated processes?**
I believe we are not ready yet. However, it is exactly in this sense that we have been working, but what happens repeatedly is that there are several failures of some automatisms of this nature (end-to-end) and we realize that we cannot trust this approach 100%, so, for simplicity and ease, we return to execution with human intervention.

Table 12 – Company answer to the first question

Question 2 – Do you consider it is possible for the company to foster individuals to participate in even more efficient and optimized processes?
Yes, totally. At this point, I believe we are on a good path, as I feel that employees show interest in this learning and strive to accompany the process improvement journey that we are on. Additionally, we have many training courses in this regard, which take place at different frequencies throughout the year, but we certainly have training in the area of process optimization with a monthly average.

Table 13 – Company answer to the second question

Question 3 – To be on this stage, we know you perform several process monitoring techniques as process auditing, analytics and mining. It has been hard to maintain this? Do you expect difficulties in this regard?
Yes, to be able to be at this level (4) we must do this type of action and also because it is mandatory for all agents of the company we supply. Therefore, process analytics is relatively easy, since our technicians must document everything on their mobile devices and this information is stored in a database that feeds a dashboard, then, the company we work for takes care of analyse the data provided by that dashboard. With regard to audits, these are generally carried out internally and we look for evidence of each stage of the process being audited. Regarding process mining, this part is very much left to the company to which we respond, I know that they choose some process occurrences – logs – stored in the system and use them to check if everything is going as expected, where are we consuming too much time/ resources and etc, so, yes, these techniques are assured in our business environment.

Table 14 – Company answer to the third question

Taking into account the outcome of this interview, one can verify that the model is plausible to be implemented by a real company, since the steps suitable for the maturity level of this company were well received and are already being planned by the company itself.

As it is natural, it was confirmed that there are obstacles that, in the case of this company, are related to the correct operation of the end-to-end automation, so, the implementation of each stage is not suitable to be done at the first try, at least, for the majority of the companies. Thus, this is an iterative and interactive process.

5. CONCLUSIONS

The present section aims to conclude this paper and here it can be read a summary of the work developed as well as limitations inherent to the present study and, consequently, the identification of opportunities for future work.

5.1. SYNTHESIS OF THE DEVELOPED WORK

The present dissertation proposes a new Maturity Model to position and leverage organizations in the journey of intelligent process automation, so that it is possible to reach, namely, the Hyperautomation.

This way, a very high importance was given to the study of the main Business Process Management Maturity Models and an investigation was carried out so that the intelligent automation component could be included in these dynamics.

Having said that, the ambition of the present study was to build a Maturity Model that aggregates the necessary characteristics to reach maturity, not only of the processes themselves, but also of their automation.

In this way, the result of this dissertation is directed to organizations/ companies, so that they can use the proposed Maturity Model as a framework that guides the process of continuous improvement of intelligent automation of processes in a flexible way, that is, the model has the ability to adapt to different business realities.

Thus, with the implementation of this Maturity Model, it is intended to offer organizations a way to reduce execution times, reduce failures and, consequently, reduce costs, with a cyclical dynamic of continuous improvement.

5.2. RESEARCH LIMITATIONS

In the Literature Review section of this dissertation, the main technologies that can be integrated into business processes were discussed, as well as the main Maturity Models based on Business Process Management techniques, with the objective to make it possible to combine the benefit of BPM models with the addition of the technological and intelligent component to them, resulting in the proposed Maturity Model.

Additionally, two frameworks were provided in the scope of the proposed MM for the classification of organizations: one using a flowchart (more restrictive) and the other based on a Machine Learning algorithm, namely the K Nearest Neighbors (KNN) (more malleable and adaptive).

However, algorithms that are more complex, such as Neural Networks or Ensembled Classifiers, were not addressed in this dissertation.

Additionally, despite an interview with a company addressing the feasibility of implementing the MM, no pilot project was carried out, i.e., the Model was not actually implemented in a company.

Thus, it can be considered that the aspects that could be deepened in this study are:

- The investigation of other algorithms to compete with KNN in the search for the most accurate classification possible.
- Conduct a project to implement the proposed MM in a real case.

5.3. Future Work

Considering the two limitations identified, it is considered that they constitute an opportunity to improve and complement the proposed Maturity Model.

This way, the further study of other Machine Learning algorithms to classify the maturity level of a company is pointed out as a possibility for future work.

Additionally, it is also considered desirable to implement this model in a company, performing a pilot exercise in which the gaps inherent to the model are expected to be identified and, consequently, creating the opportunity to improve it.

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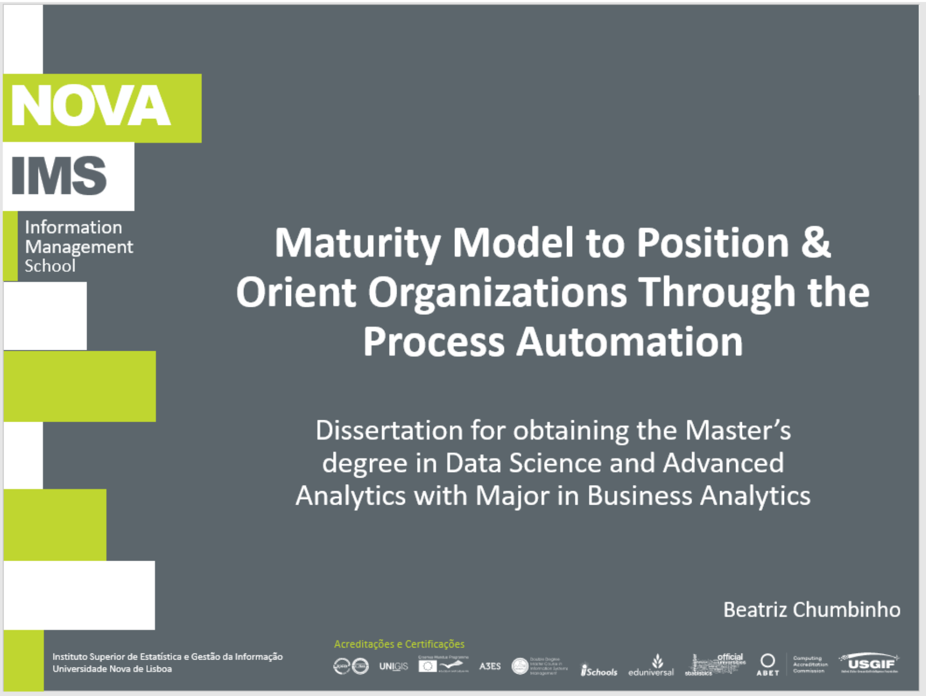
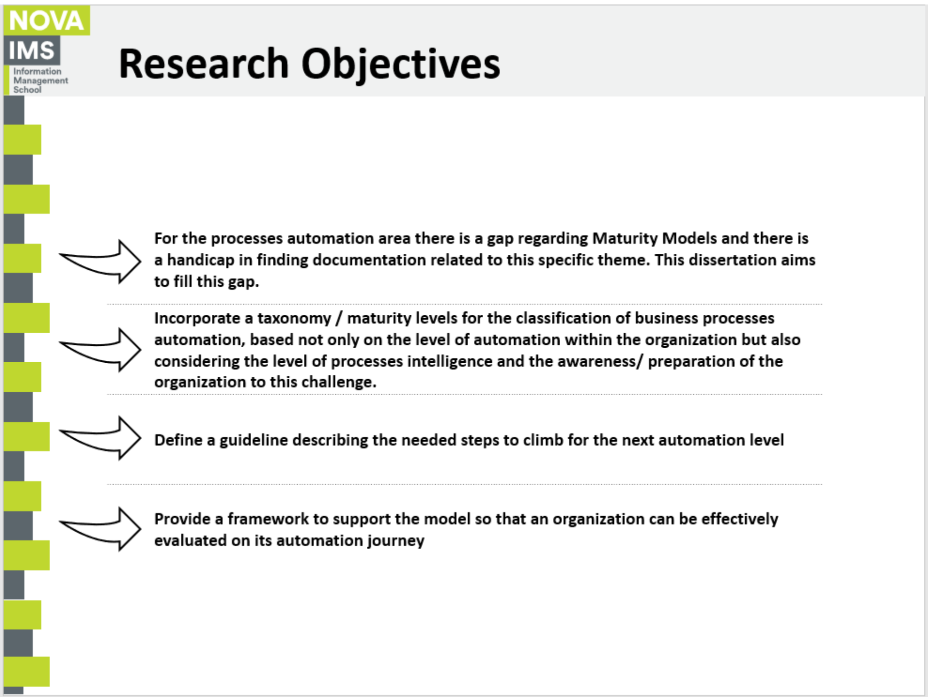
7. APPENDIX

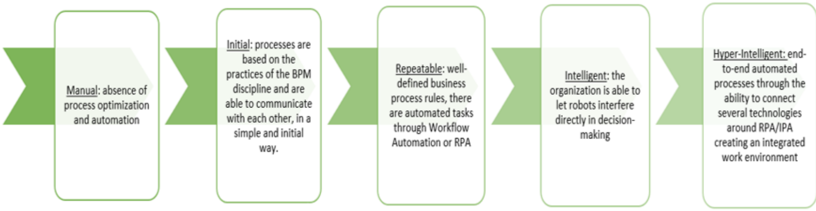
7.1. SLIDES USED FOR THE EXPERT'S INTERVIEWS





Framework

The model is composed of 5 levels of maturity where the Manual represents the beginner stage and the Hyper-Intelligent represents the most advanced level.



Framework

For a better understanding on the proposed MM, the table below provides the detail of the levels for each component as well as the actions needed to climb for the next stage:

	People & Culture	Processes	Automation	Needs
Level 1 Manual	Individual work and lack of communication within the organization.	Processes are not formally defined and there is no articulation between them	No automation of processes	• Define and improve existing processes • Make use of Governance Methodologies • Improve the communication both within employees and processes • Counteract the isolation of existing systems and automation
Level 2 Initial	There are standards defined to align the work of different business units but there is still existing a lack on uderstanding of cross-departmental proceses needs	Processes are based on practices of the BPM discipline and are able to communicate with each other, in a simple and initial way i.e. processes are defined at least at a local level	Existence of a BPMS in order to be enable the monitoring and improvement of processes	• Measure the performance through defined metrics • Describe the rules for basic tasks – if then else • Automate basic and well-defined tasks • Implement the practice of defining process leaders who have the functions of improving and maintaining core processes.
Level 3 Repeatable	There is connection between departments and there are process leaders in charge of the process maintenance and improvement	Performance metrics are fequently used to monitor porcesses and the organization has its focus on business processes	Workflow Automation or RPA – Robotic Process Automation to enable the automation of simple and repetitive tasks	• Integrate the existing RPAs • Add artificial intelligent to bots in order to allow them to judge • Continuously monitor processes so they can improve • Foster training initiatives for employees within the scope of business processes
Level 4 Intelligent	There are learning activities in place in order to encourage employees to be committed to processes´optimization	The organization focus is on continuing to improve the efficiency, effectiveness and solidity of processes and the integration of the existing automation	IPA - software that can do analytics on data from different sources, in a structured and unstructured way, as well as coordinate the different robots.	• Automate end-to-end processes • Automate processes and implement seamless communication between them • Foster the participation of leaders and employees in the search for increasingly optimized processes
Level 5 Hyper-Intelligent	Everyone in the organization is seeking for gaps/bottlenecks in the processes, to improve them and the training initiatives are constantly being updated	Integral process integration accross the ecosystem of the company	Hyper-Automation: promoting end-to-end automated processes through the ability to connect several technologies around RPA/IPA creating an integrated work environment	• Keep the monitoring of the processes' performance • Keep evaluating gaps and bottlenecks • Update the environment when changes occour • Keep trainning employees with the best practices

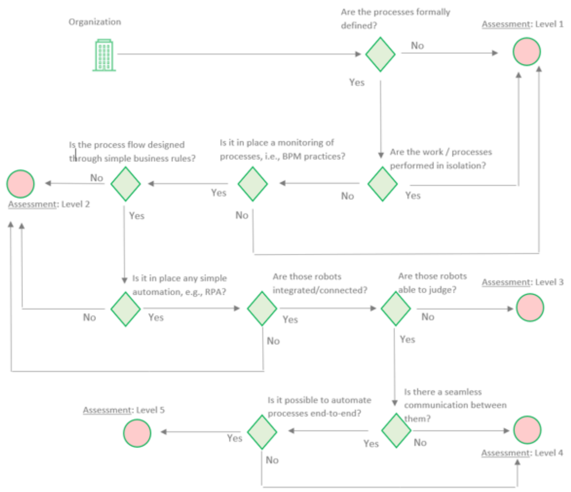
Framework

The study presents two ways to classify the Maturity Level of a company:

1. Through a flowchart;
2. Through a classification model using KNN.

The KNN brings the opportunity to retrieve more realistic and less limited outcomes since the flowchart classification is very restricted, e.g., to reach the maturity level 4 all the requirements of levels 1,2, and 3 must be satisfied and sometimes this is not strictly necessary.

Flowchart method



Need to fulfil 100% of the requirements to pass to the next level: very restrictive and sometimes might be hard to adapt to reality.

KNN method

```
1 df.iloc[24:25, :-1]
```

	Defined Processes	Governance	Processes' Comunication	Isolated Systems	Performance Metrics	Rules defined	Automated tasks	Process Leaders	RPAs	AI	Processes monitoring	Training for Employees	Process Analytics	Process Mining	Proce Auc
24	1	1	1	1	0	0	0	0	0	0	1	0	0	0	

```
1 df.iloc[89:90, :-1]
```

	Defined Processes	Governance	Processes' Comunication	Isolated Systems	Performance Metrics	Rules defined	Automated tasks	Process Leaders	RPAs	AI	Processes monitoring	Training for Employees	Process Analytics	Process Mining	Proce Auc
89	1	1	1	1	0	0	0	0	0	0	0	0	0	0	

Use Case

```
## Use Case Instance
UseCase_1 = df.iloc[24:25, :-1]
```

```
UseCase_2 = df.iloc[89:90, :-1]
```

```
MaturityModel_1 = classifier.predict(UseCase_1)
MaturityModel_2 = classifier.predict(UseCase_2)
```

```
MaturityModel_1
```

array([2], dtype=int64)

```
MaturityModel_2
```

array([2], dtype=int64)

Shows that 2 organizations with some different characteristics / requirements can share the same level: more compliant with the reality (in this case both are in the 2nd level).

Interview Questions

1) Since none of the current models can be used for the implementation of automation, do you think it is useful to create a new Maturity Model that allows guiding the path of processes' automation of an organization?

2) What is your opinion on the suitability of the proposed Maturity Model?

3) What improvement recommendations do you propose to enrich the proposed model