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Process Modelling, Analysis, and Redesign

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Internship report presented as partial requirement for obtaining the Master's degree in Information Management

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A BPM APPROACH IN A SMALL AZOREAN COMPANY: PROCESS MODELING, ANALYSIS, AND REDESIGN

by

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Internship report presented as partial requirement for obtaining the Master's degree in Information Management/ Master's degree in Statistics and Information Management, with a specialization in information systems and technologies management.

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ABSTRACT

Process efficiency has been a concern for organizations since the beginning. Numerous methodologies to improve process efficiency have been proposed and developed throughout the years; one of those methodologies is business process management. Business process management can bring to organizations a performance improvement, reduce costs and process cycle time, and improve overall customer satisfaction. The proposed project's goal for the internship was to study the organization's process by identifying, modeling, analyzing, redesigning, and implementing the proposed changes. The organization is focused on the sale and service provider of technology products and accounting services in the Azorean environment. After some analysis and deliberation, the most adequate process to receive this business process management approach was the Technical Assistance process.

KEYWORDS

BPM; BPMN; Process modeling; Process Analysis; Information Management; Process Redesign

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LIST OF ABBREVIATIONS AND ACRONYMS

BPG	Business Process Governance
BPM	Business Process Management
BPMM	Business Process Maturity Model
BPMMM	Business Process Management Maturity Model
BVA	Business value-adding
EPM	Enterprise Process Management
ERP	Enterprise Resource Planning
IT	Information Technology
KPI	Key Performance Indicator
NVA	Non-value adding
QMS	Quality Management System
OPM	Operations Management
RCA	Root-cause Analysis
ROI	Return on Investment
SLA	Service Level Agreement
TQM	Total Quality Management
VA	Value-adding
VAA	Value-Added Analysis
WIP	Work-in-Process

1. INTRODUCTION

1.1. Background and Problem identification

Processes are the core of a business; they exist everywhere and are essential for the business to run. Well-developed and monitored processes help companies adapt to changing environments, comply with the growing number of legislative requirements, and influence the revenue and costs of an organization. (Dumas et al., 2018)

In a world where adaptability and continuous improvement are crucial for the survivability of a company, business process management offers relevant contributions to companies by delivering improvements in organizational performance and service quality.

SISDIAS has accepted the proposal of an application of this BPM approach, with the primary goal of identifying and eliminating waste and optimizing core processes, saving time, reducing costs, and increasing customer satisfaction whenever possible. The company never had similar projects, now being opened to attempt this approach.

SISDIAS, Sistemas de Informação e Serviços, Lda., was founded in November of 2001 by Ricardo Dias. The company dedicates itself to the commercialization of informatics and information systems products and services.

When it was created, it did not have a very in-depth digital culture, only adequate to its time, but with the world's technology evolution over the years, it has been adapting and staying updated. In the beginning, it was a one-of-head office in the city of Angra do Heroísmo, with the main project of working with informatics and associated services. The project of working with parishes came up right in the beginning and has grown to start working in different Azorean islands. In 2002, it started by implementing the accounting system POCAL in Terceira Island and 2003 in Graciosa Island. In 2005 it arrived at São Miguel Island, focusing on software, and 2009 in accounting. Since 2013, there have been investments in representation processes in São Miguel Island to improve the time and efficiency in aid of its client's needs. The headquarters in this island changed location three times, starting in Ponta Delgada, then Vila Franca do Campo, and as for 2020 in Lagoa, where new headquarters are being prepared to be opened in 2021.

In 2009 the company arrived at Faial and São Jorge islands, in 2015 to Flores and Pico, and finally to Santa Maria island in 2017.

1.2. Study Objectives

The main objectives set for the internship can be defined as the application of the different steps of the business process management methodology issued by Dumas et al. (2018). Regarding the business process management lifecycle, the objectives can be defined as:

1. Assess the company's maturity level for BPM initiatives.
2. Identify the company's business processes and their relationships and establish a criterion for their prioritization.
3. Modeling of the current state of the business process, "AS-IS" models.
4. Analyze the "AS-IS" process and assess its performance's potential issues and space for improvement.
5. Identify and analyze potential solutions for the previously defined issues. Redesign the process into a "TO-BE" version.
6. Implement some of the changes proposed in the previous step.

It will be necessary to make an assessment to understand the work in progress in the company regarding its digital transformation, as well as what are the specific company goals and strategic importance of the transformation. The business process management addresses the needed innovation and adaptability of business processes, providing a platform for continuous improvement. Business process management is at the core of this digital transformation ("Business Process Management Enabled Digital Transformation in 2020", 2020).

Controlled data accessibility is key for efficient work from the employees. The easy and fast access to different needed sources can unclog work impediments. Business process management can be used as a tool to balance data overload and insufficiency by controlling the accessibility of data required for each circumstance (Matei, 2011).

1.3. Study relevance and Importance

Optimizing processes through a business process management approach can bring the company a handful of advantages, from an assured quality and increased customer satisfaction to market compliance and reduced risks. This strategic element is crucial for modern organizations, granting more efficient work by eliminating unnecessary steps and automating others to save time, reduce errors and avoid duplicate work. It provides more clarity on what should be done, from documenting who is the process owner to which information should be registered (ABPMP, 2013). It can also increase customer satisfaction by allowing for better, quicker, and more accessible customer service. It can enable better compliance with laws, regulations, GDPR, for example, and technical certification standards, like ISO-9001:2015, which is a set of standards that define the implementation and maintenance of a Quality Management System (QMS) (Abu Al-Rub et al. 2020).

Due to the size of SISDIAS, there are no current or past projects in this area. Therefore it can be expected a level of resistance to change when it comes to the people that actively work in the non-optimized processes.

A business process management approach to the company can bring reduced costs and higher revenues as economic benefits since the proper implementation of this methodology can reduce waste and decrease the costs associated with specific business process execution (Rudden, 2007).

SISDIAS does not have implemented any automated ways of gathering information during the processes. This can be seen as an issue or limitation when analyzing the performance of the processes. It will be necessary also to define metrics and key performance indicators (KPI's) to evaluate the performance of the processes. An assessment of different software needs to be made to understand what the best options are considering the size and goals of the company.

1.4. Report Structure

The internship report is presented in five sections: introduction, literature review, methodology, results and discussion, and conclusion and limitations.

The introduction section aims to provide the reader with a first understanding of the set objectives, the relevance and importance of the study presented to the company, as well as the company's background.

The literature review provides the theoretical context on the areas to be applied in the project. The topics included in the literature review are the concepts of business process management, including its techniques, possible benefits, barriers, and critical success factors, the BPM lifecycle and its different stages, and enterprise process management and its concepts, with an overview of business process and business process management maturity models, context framework and business process governance.

The methodology chapter mentions what metrics will be measured during the project, what notation language will be used, and a small comparison between possible tools to be used.

The fourth chapter, results, and discussion is aimed to provide the different results of the analysis made to the process in question by following the different stages of the methodology, as well as the demonstration of the maturity assessment of the organization regarding BPM initiatives.

Finally, the last chapter refers to some conclusions and summaries about the conducted internship and project.

2. LITERATURE REVIEW

In this chapter, there will be a review of specific topics and concepts utilized to carry out the internship and its project. As Paul and Criado (2020) state, a well-researched and written literature review can provide the reader with a comprehensive and clear overview of the topics, synthesizing prior studies and enhancing the knowledge foundation. This literature review can be considered as an “academic hearth” of the internship report. It is here that the relevant theory and research that guided my work are identified and exposed.

This section starts with an overview of BPM. It then reviews the BPM lifecycle discussed by Dumas et al. (2018), having a closer look at each of its phases. A review of EPM (Enterprise Process Management) is then made, including process maturity, business process maturity models, BPM context framework, business process governance, and an overview of a case study in the context of BPM.

The main process for the literature choosing method was by researching online using google scholar, ScienceDirect, and by asking for recommendations from professor Frederico Cruz.

2.1. BUSINESS PROCESS MANAGEMENT

Before diving into the concepts of BPM, its lifecycle, and approaches, it is necessary to understand the core of it all, which are processes. Processes are everywhere in an organization and even in each person’s day-to-day life.

We cannot carry out our lives without processes. Oxford Advanced Learners Dictionary defines process as "A series of actions or steps taken in order to achieve a particular end." ("Process", 2021), this can be applied to the context of an organization, with processes existing in every department and at any time. Also, in the daily activities of a person, for example, when someone is following a new recipe, they are carrying out a process, an input is given (the raw ingredients), a series of steps are being taken to achieve an end, which in this case is the meal.

A business process is a specific type of process that, as the name suggests, focuses on steps and activities by either humans or machines to create value for a customer by transforming specific inputs into outputs (Davenport, 1993). Figure 1 demonstrates that a process is composed of different elements. The input representing the materials and components necessary to start the process, the processing phase, where those inputs are worked on, the resulting outputs (e.g., End product), and the feedback which connects the output to possible new inputs regarding the customer feedback and managerial ideas.

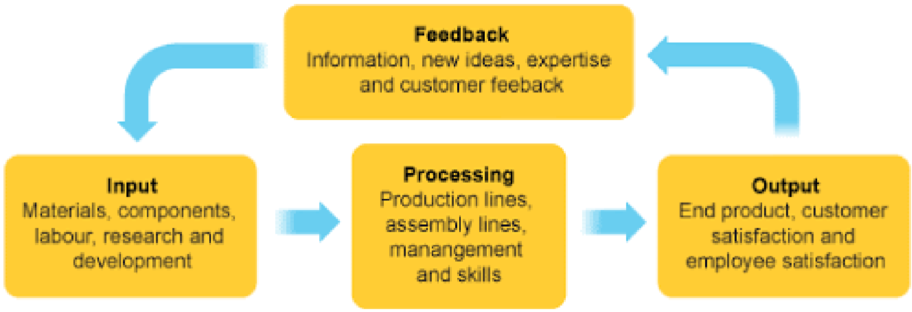


Figure 1 – Transformation Model (2013).
Source - https://businessfortheyoung.weebly.com/input-process-output/archives/12-2013

Dumas et al. (2018) define a business process "as a collection of inter-related events, activities and decision points that involve several actors and objects, and that collectively lead to an outcome that is of value to at least one customer." Being then the basic unit of business value inside an organization.

With the rapid technological development and globalization, companies have been faced with the challenge, of great importance, of performing effective management over these business processes. The rise in orders, the need for faster information transferability, and decision-making influenced this need (Ko et al., 2009). This challenge raised the need for different solutions, which came in different disciplines, including BPM and Total Quality Management (TQM), Operations Management, Lean, and Six Sigma. (Ko et al., 2009).

Pyon et al. (2011) define BPM as a discipline that directly supports business processes by using a set of approaches to design, analyze and control operational processes involving different actors, such as people, applications, documents, and the organization. Lemańska-Majdzik & Okręglicka (2015), suggests that it is necessary to adopt the customer's point of view when taking a process approach since the end goal of the processes is to define a structure for the organization that leads to the production of value to its customers. BPM provides the organization with tools to increase both its effectiveness and efficiency, is a great contributor to its performance and competitiveness, factors that each organization needs to be able to survive and scale, becoming a more and more important aspect for its innovation and transformation (vom Brocke et al., 2014).

As mentioned above, BPM is not alone in the disciplines concerned with performance improvement. TQM is an approach that is said to have inspired BPM (Dumas et al., 2018; Stravinskiene & Serafinas, 2020). However, this discipline focuses more on the products and services themselves, while BPM focuses on the improvement of the processes that create said products and services. BPM also differs from Operations Management in the sense that despite sharing multiple techniques for operation optimization, such as modeling and simulation, OPM is concerned with the aspect of controlling existing processes without putting them through change, while BPM changes existing processes with the goal of improving them. BPM has also absorbed practices utilized by the Lean Six Sigma disciplines. Since Lean focuses on the elimination of the activities that do not add value to the customer, an orientation that can also be found in BPM an example of this is the Value-Added qualitative analysis, discussed later, and Six Sigma being a set of practices that focus on the minimization of defects, techniques of this nature can also be found in BPM, by applying Waste Analysis, which focus on the same end. (Dumas et al., 2018)

The BPM benefits are said to range from the enterprise level, by enabling a compliance improvement by monitoring the processes, since organizations face compliance risks through wronginappropriate response times, and assessing costs of processes and activities inside those processes facilitates the overall cost control and possible cost reduction. BPM also benefits on the customer front by impacting customer satisfaction due to aid on process efficiency, meaning meeting time expectations and allowing for the possibility of price reduction through cost reduction. The benefits to management can be seen as a constant improvement to plans and projections through enabling management to make needed medium- and long-term changes. Enabling the process actors to have a better understanding of the whole organization's process map and interaction by having well-documented processes. (ABPMP, 2013).

According to Jeston & Nelis (2013), several different drivers and triggers may cause an organization to consider BPM. These drivers and triggers can be found in different sectors of an organization, those being: the organization itself, management, employees, customers/suppliers/partners, products and services, processes, and information technology. In the sense of the organization, there might be difficulty coping with sudden and high growth, or even the need to meet compliance and regulations criteria—management by needing to provide managers with more control over their processes. The employees also might drive the company to consider a BPM initiative by stating their low satisfaction about certain aspects regarding their process lifecycles. Customer, suppliers, and partners may express their dissatisfaction with services, being it by unavailability or incompetence of the staff. If products and services are complex, or even if there is low business agility, e.g., long lead times to market. The process quality is poor, and a great quantity of rework is being done. There are too many unnecessary hand-offs in processes. Regarding information technology, the organization may be introducing new systems like CRM or ERP systems, or even a totally new IT infrastructure.

It is important to note that, according to Dumas et al. (2018), there are some critical barriers to BPM success, namely the focus on the use of BPM tools, methods, and techniques, opposed to the business goals, where organizations misplace the said techniques and lose the focus on the strategic goals. Another barrier is that organizations may discard other management disciplines that could bring value to them instead of using them in order to reinforce BPM. Since BPM is of a holistic nature if organizations treat each process and each BPM project separately, it can create issues, from participants' confusion on the objectives and customers needing to interact with the organization through different changing processes. Finally, people tend to resist change. This barrier is not specific to BPM. However, it is one that should always be in mind when enrolling in a BPM initiative.

2.2. BPM Lifecycle

The ABPMP (2013) states that "business processes should be managed in a closed-loop cycle to maintain process integrity and enable continuous improvement". This view of managing the business processes enables organizations to adapt to changing market environments (Liu et al., 2009).

There have been different approaches for the definition and establishment of the BPM lifecycle. However, they are all continuous and iterative with integrated activities. ABPMP (2013) defines the different phases of the BPM lifecycle as Planning, Analysis, Design and Modeling, Implementation, Monitoring and Control, and Transformation. Throughout this report and the internship, the methodological approach to the BPM lifecycle was the one proposed by Dumas et al. (2018) that has the stages of Process Identification, Process Discovery, Process Analysis, Process Redesign, Process Implementation, and Process Monitoring and Controlling. This lifecycle model aims to define the starting point of a BPM initiative inside the organization, viewing it as a continuous cycle with different and specific tasks and objectives in each of its stages.

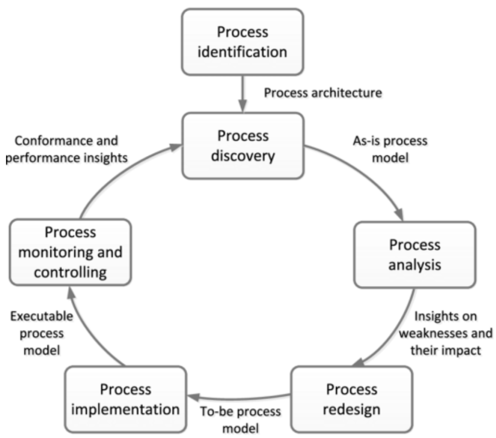


Figure 2 – BPM Lifecycle.
Source: (Dumas et al., 2018)

2.2.1. Process Identification

The lifecycle starts with the Process Identification phase, where, as the name suggests, the processes inside the organization are identified. Additionally, their relationships are delimited, and the business problem is posed. It is in this phase where criteria for process prioritization is established since is most organizations do not have enough resources to apply this BPM approach to every process in detail, being considered non-cost-effective. Therefore it is essential for each organization enrolled in a BPM initiative to focus the attention on a subset of processes (Cho & Lee, 2011; Dumas et al., 2018). The prioritization consists of a set of different approaches to the business problem, importance (business impact), which focuses on the weight each process has inside the organization's strategic goals, dysfunction, which takes into consideration which processes present more, and constant, problems, and feasibility, that is based on how likely a process is of being successfully managed. It is also in this phase where process performance metrics and measures should be defined. These metrics can range and depend on each organization and process. Some examples of typical metrics are the cost-related metrics, being, for example, the cost of each process, time-related metrics focusing on the time spent between the beginning and the end of a process, and error-related metrics that focus on the quality of the business process. (Bezerra et al., 2018). The identified processes can be categorized according to Michael Porter's Value chain model. Core processes are those that directly influence and increase added value for the customers. These use typically include processes that create new products or services and that contribute to customer satisfaction. These core processes demand specific and careful support, planning, and organizing, which are, fundamentally, the other types of processes, support, and management processes (Gošnik, 2019). Support processes exist to assist the execution of core processes. Examples of support to core processes are supply procurements and machine maintenance. However, support processes also aim to help management processes, with the administrative processes including accounting and human resources. Management processes provide the means to measure and control quality and ensure the desired performance outcomes, helping decision making, guiding, and enabling the organization to achieve its strategic goals (Lehmann & Kutnick, 2012; Zelt et al., 2018).

The output of this phase is a process map/architecture which represents the processes and their relationship. (ABPMP, 2013)

2.2.2. Process Discovery

According to Dumas et al. (2018), the next phase of the BPM initiative is process discovery. This phase encompasses the creation of different as-is process models. These models reflect the current activities and events, and the people's perception of them, inside the organization. Their goal is to facilitate communication between stakeholders; consequently, they have to be easy to understand between all parties involved. Several different modeling languages and notations, such as Business Process Modeling Notation (BPMN), and Unified Modeling Language (UML). Dumas et al. (2018), also state that this phase is also denominated as process design in the literature. However, he suggests that process discovery is a more appropriate name since the process already exists, at least implicitly. In order to be able to complete this phase successfully, it is critical to have an excellent and in-depth understanding of the operations of the business processes. The process discovery phase can be divided into four further sub-phases. They are defining the setting, gathering information, conducting the modeling task, and assuring process model quality. The set definition is dedicated to an assembly of a team of domain experts and business analysts. These two positions complement each other during the BPM approach since domain experts are the people that know how the processes work internally, needing to provide the business analysts with the details of each domain. With these details, the business analysts can create the models that the domain experts in the other end are not familiar with and possibly do not fully understand (Leopold et al., 2012).

The task of gathering the needed information to be able to understand the flow and components of the process can be challenging. This happens due to a fragmented knowledge of the process, e.g., a process has, typically, multiple actors and domain experts. Therefore a process analyst needs to confirm and discuss the process with all the participants. This is because each different domain expert has different knowledge about how the process is carried out. There are multiple methods for a process analyst to gather process information: Evidence-based discovery, interview-based discovery, and workshop-based discovery. Each of these methods presents pros and cons, and most of the time, they can complement each other to provide a richer and more accurate perception of the process. Evidence-based discovery can be further divided into Document analysis, observation, and automatic discovery. Document analysis represents the analysis carried out to already existing documentation, being it from process descriptions, handbooks, organizational charts, etc. (Rosenkranz et al., 2010). This method, even though very objective in the information that it provides, a lot of time is out of date. Observation discovery is the act of presently following the process being carried out, the issues with this approach are that the business analyst can only have a small picture of the process since he only observes a limited number of instances, and the process participants are likely to change the way they act during the process to what they think the business analysts want to see and not what really happens if he wasn't there. Automatic discovery is made with the support of the information systems, making use of stored event logs. (Dumas et al., 2018)

Interview-based discovery methods consist of the execution of one-to-one interviews with domain experts to enable a more in-depth understanding of how processes are performed. It is important to understand that, as mentioned above, knowledge is typically subdivided across multiple actors. Therefore interviews need to be conducted with various domain experts. Workshop-based discovery has the same basis as interview-based discovery. However, there is a more comprehensive broader number of participants and roles. This method can be used to immediately start the modeling process during the said workshops. Workshop-based discovery provides rich information with direct resolutions of conflicting views; however, it can be costly, and it is necessary to have the availability of several stakeholders simultaneously. (Stirna el. al, 2007)

The process modeling can be seen as a complex task. Therefore Dumas et al. (2018) suggest that this task should be subdivided into five steps: Identification of process boundaries, identification of activities and events, identification of resources and their handovers, identification of the control flow, and identification of additional elements.

Identifying the process boundaries means identifying what events trigger the beginning and the end of a process, i.e., the receipt of a customer's complaint can trigger the process of complaint handling, and the output of this process, the handling of the customer's complaint, ends the process.

Identifying the activities and events of the process is important to complete at the next stage due to allowing domain experts to clearly state what they are doing, even if they do not know that it is part of an overarching business process (Dumas et al., 2018). Activities in a process represent the tasks and subprocesses undertaken to perform the necessary work. There are multiple types of tasks and subprocesses (Aagesen & Krogstie, 2014). Events are triggers that may start or end the process, already identified in the boundaries of the process, but also may occur during the process. A more in-depth look into the different nodes will be undertaken in the BPMN section of this report.

When the set of activities and events are clearly identified, it is possible to attribute resources to each one of them, either being human or technological resources. This information enables the creation of pools and lanes. Each pool typically represents an organization, where a lane represents an entity, i.e., a department, within that organization (Owen & Raj, 2003). Since the order of the activities is not clearly defined yet, it is necessary to also identify the points in the process where work is handed from a resource to another (Dumas et al., 2018).

Control flows relate to questions of when and why activities and events take place, represented by gateways (Dumas et al., 2018). Gateways represent mostly points of decision inside the process. However, different types of gateways represent different questions made inside the process, i.e., if it is an exclusive gateway, a "question is asked" where only one output of that gateway can take place, if, in the other hand, the gateway is inclusive there can be one or more outputs of the gateway, whatever is appropriate for that situation. (Dijkman et.al, 2008)

Additional elements such as data objects, data stores, and exception handlers are identified in the last phase of process discovery.

To assure a quality model, it is necessary to assess the produced model with, preferably, multiple process analysts and domain experts. Focusing on syntactic, semantic, and pragmatic quality. Syntactic quality represents if the model complies with the syntax defined by the chosen process modeling notation. Semantic quality handles the questions if the model really represents what the process currently looks like. The domain experts can provide important inputs to this validation. Pragmatic quality assures that the models are reader-friendly and that every stakeholder can comprehend their schema (Dumas et al., 2018; Fellmann et al., 2013).

2.2.3. Process Analysis

To be able to update and improve an already existing business process, it is vital to have a comprehension of his state and how it achieves strategic business objectives. Process analysis is a discipline that provides this understanding. It can be carried out through various means and techniques, being an essential tool to evaluate the processes' efficiency. (ABPMP, 2013)

Process analysis can be seen as having two distinct and characterized types, qualitative and quantitative process analysis (Dumas et al., 2018).

2.2.3.1. Qualitative Process Analysis

Qualitative process analysis uses subjective judgment based on "soft" or non-quantifiable data. Often tools for this type of analysis are borrowed from Lean and Six Sigma (Conger, 2010).

Value-Added Analysis (VAA) aims to remove nonessential process tasks, e.g., waste. Shou et al. (2019) demonstrate that "value is defined from the viewpoint of customers, with the capability to deliver exactly the customer needed product or service with minimal time at an appropriate price, and value-adding activities contribute directly to creating product or service customers really want". At the same time, waste is any task that consumes the organization's resources without creating any customer value. To apply this technique to a process, it is necessary to first have the process modeled and mapped, which, by following the lifecycle accordingly has to already been completed in the process discovery phase, then, the process and process activities are decomposed in more specific steps, activities might be composed of multiple necessary steps to be able to be completed, this decomposition is, done by the process analysts through observation and interviews with process participants. According to Dumas et al. (2018), the next step in this analysis is to clearly identify the customer of the process and what positive outcomes he seeks from the said process. These outcomes are the ones to be considered as adding value to the customer. Thus, steps that contribute to these outcomes are considered “value-adding” steps (VA).

Dumas et al. (2018) propose a terminology of “business value-adding” (BVA) steps to those that do not directly contribute to positive outcomes to the customer but are necessary, or valuable, for the business to function well, with fewer issues, or are necessary due to regulatory requirements.

The third and last classification is the “non-value adding” (NVA) steps, which are all the steps that do not fall in either one of the aforementioned categories.

Upon having completed the classification of the steps, an evaluation of each NVA step is made to have a better understanding of if and how this step can be eliminated. Handovers, which are mostly considered NVA steps in the process, can, most of the time, be eliminated by the implementation of an information system (Dumas et al., 2018). Whenever possible, waiting times should be eliminated entirely as they are considered simple waste (Conger, 2010). While analyzing the possible waste elimination, it is critical to understand the pros and cons that each proposed solution can bring. These issues also lie in the process redesign phase, which is overviewed later in this report.

It is also proposed to minimize the BVA steps whenever possible. However, this task should be done with some caution. Since these steps can be essential for regulation requirements, it is important to first map the BVA steps to the company’s goals and requirements. (Dumas et al., 2018)

Waste analysis is the technique of looking at the process and identifying the “waste” that exists in them. Some of this waste can take place not only within steps but also between them. The waste analysis derives from Lean, or Toyota Production System (TPS). Taichii Ohno identified and classified seven different types of waste. They are as follows:

- Transportation
- Motion
- Inventory
- Waiting

- Overproduction
- Overprocessing
- Defect

Later, an eighth waste was defined as the “Unused Talent” when the TPS was adopted in the western world.

Transportation and Motion waste can be categorized as a movement. Transportation waste involves the movement of materials in the supply chain, from the suppliers to the customer, waste is created in this movement, and costs are created on the product and affect customers, causing delays in the delivery of the order. In manufacturing, transportation waste might originate due to great distances between warehouses or service departments to production facilities (Soliman, 2017). In a business process, this waste also occurs, for example, when documents are transported from one process participant to another.

Motion waste refers to both human and layout unnecessary motion. Human unnecessary motion is where workers have to move around internally in the facilities. The layout dimensions refer to poor workplace arrangement, which eventually leads to waste of movement. This type of waste is more common in manufacturing processes than it is in service’s processes (Wahab et al., 2013)

Soliman (2017) considers inventory waste to be one of the most significant types of waste. The hoarding of unnecessary inventory can bring additional labor and equipment to allow for that unnecessary additional handling. Inventory types are the raw material inventory, the work-in-process (WIP) inventory, and the finished product inventory. WIP relates to the materials and parts that are not yet part of the finished product but are no longer sole materials (Barrak et al., 2017). In service processes, in-office inventory waste could be considered pending files or storing unused records and obsolete files.

Waiting waste type relates to the time dimension, involving the wait for materials, maintenance service, preventive maintenance, tasks waiting for resource availability, or resource idleness. (Soliman, 2017). “Reducing cycle time by eliminating waiting within the work sequence can have a profound effect on productivity” (Art of Lean, 2000, p.11)

Overproduction waste is directly related to inventory waste. Making more products than needed or overcapacity of what is being sold can waste a high amount of money due to the costs of production and the costs of the inventory losses (Skhmot, 2017). Regarding the service’s processes, overproduction waste may come in the form of simply instantiating processes that do not add value upon completion, i.e., printing documents before they are required, or even if they end up not being required.

Overprocessing waste represents the unnecessary extra efforts during the process, whether manufacturing a product or delivery of service while integrating requirements not requested by the customer. (Furterer, 2009)

The last type of waste that will be reviewed is defect waste, also denominated as correction waste. This waste results from inadequate internal quality, by producing goods that need a rework or providing services with errors (Art of Lean, 2000, pp.10). Soliman (2017) proposes that a standardization of the work procedures is a possible solution to mitigating the failures of products and services and enhancing the overall delivery of quality by the organization.

Since processes need to be handled with the notion of continuous improvement, Dumas et al. (2018) say that independently of how much improvement a process has received, there is, and always will be, more room for improvement due to it suffering from several issues, being it, errors, misunderstandings, incidents, or unnecessary steps performed daily. These issues, therefore, need to be documented. The information regarding these issues needs to be collected by the process analyst through multiple interviews with different stakeholders, Dumas et al. (2018) warn that business analysts need to gather information from all stakeholders, being process participants and process owners, since the inputs of these different perspectives can raise very different issues, from the performance objectives not being met to process participants complaining about insufficient resources and errors coming from customers.

Root cause analysis (RCA) is a set of techniques used to analyze the factors that affect the variation in performance or that influence an event to negative outcomes. These techniques can be seen as assets for the development of effective strategies to combat specific issues (Dumas et al., 2018; Brook et al., 2015). These techniques are not restricted to a business process analysis application. It can also be used to identify the root cause of errors in products.

One of the most common RCA techniques is the Why-Why diagram, also known as tree diagram or 5 whys, as shown in figure 3. The basis of this technique is to ask the question of "Why does this happen?" consecutively, at least five times, until possible factors are identified and then thoroughly analyzed.

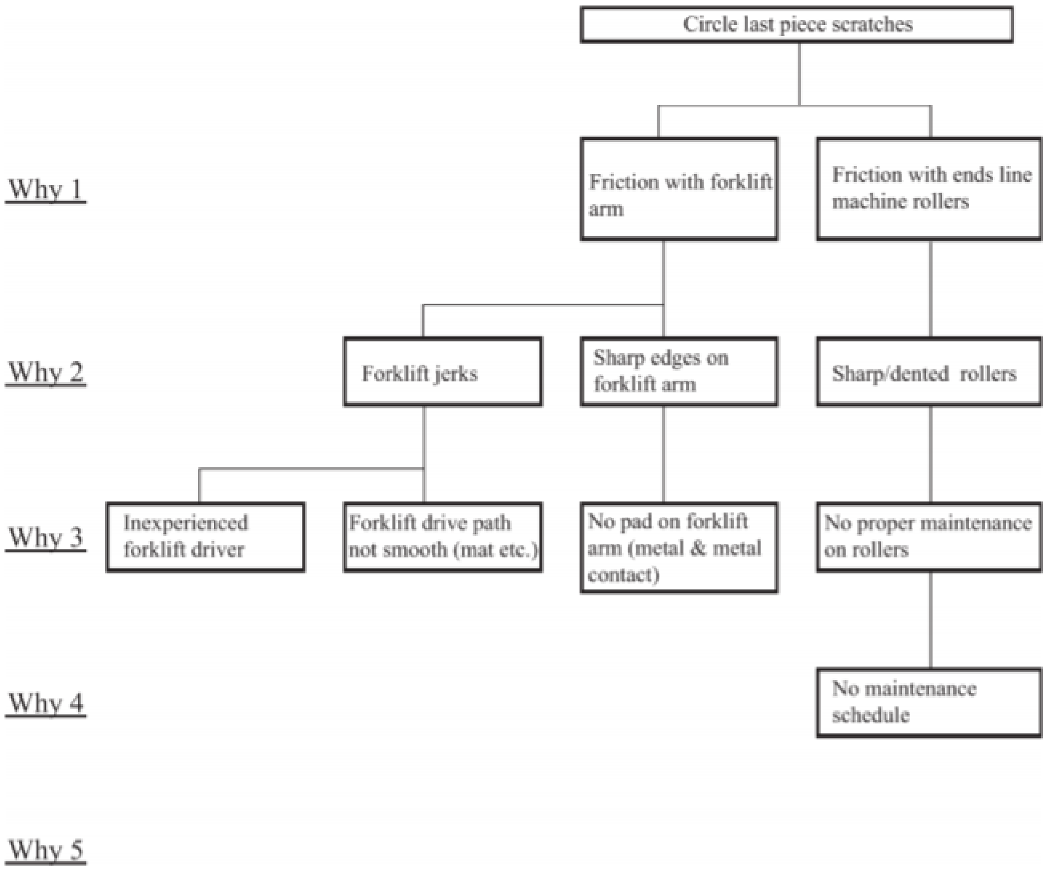


Figure 3 – Why-Why Diagram
Source: (Murugaiah et al., 2010)

It is important to understand that this technique is dependent on the biases of the participants. Ayad et al. (2010) present the use of this technique where a manager decided to apply it after multiple complaints of a customer about wrong product delivery, gathering the Human Resources Manager, his Assistant Manager, and the employee involved. After asking why the product was delivered wrongly to the different participants, the responses were contradictory, where the Human Resources Manager attributed the root cause to the Assistant Manager, the latter attributed the root cause to outdated training materials provided to the employee—concluding, then, that the Why-Why diagram's accuracy depends on the critical thinking of both the analyst and the people being interviewed.

Cause-effect diagrams describe, graphically, the relationship between a certain outcome and all the factors that influence it, "helping to identify, sort, and display causes of a specific problem or quality characteristics" (Ahmed & Ahmad, 2011)—providing the means to identify the root factors and to define risk reduction strategies and the development of action plans.

Dumas et al. (2018) present an example of a categorization of the cause-effect technique, the 6Ms:

Categorization	**Description**
Machine	Technology
Method	Process
Material	Raw Materials/Consumables/Information
Man	Physical/Knowledge work
Measurement	Inspection
Milieu	Environment

Table 1 – 6 M's Cause-Effect diagrams
Source: Adapted from (Dumas et al., 2018)

Each different factor tackles a possible field where the issue can be found in. The machine category represents the factors connected with technology, e.g., system crashes in the information systems or redundant data across systems. The Method represents those factors derived from the way the processes are understood and performed; lack of communication and unclear assignment of decision-making are examples of this factor. Material factors derive from either raw materials, consumables, or even information that, when wrongly handled, can lead to possible issues. When a step of a process is mishandled or wrongly assessed, the factor is considered a Man or Person factor. Measurement factors are related to a miscalculation in specific measures during the processes. Finally, the step of Milieu represents the factors deriving from the environment in which the process is being executed, meaning, factors originating from external actors, i.e., customers, suppliers. All of these categorizations are only meant to serve as guidelines and are not fixed. Different categorizations fit different realities. A categorization of the 4 S's can be used in the service industry, Surroundings, Suppliers, Systems, Skills. (Dumas et al., 2018)

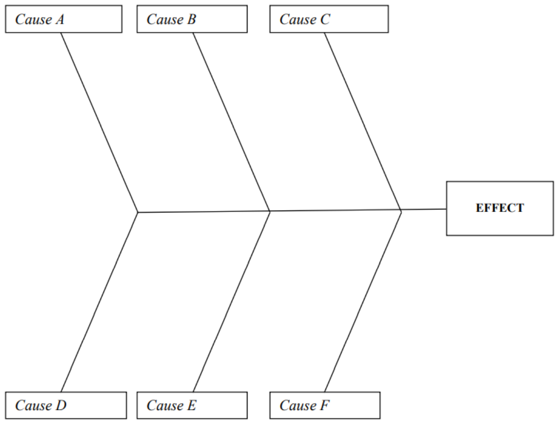


Figure 4 – Cause-Effect Diagram
Source: (Coccia, 2018)

When these techniques are applied and the root factors behind a given issue are identified, it is important to understand the impact of those same issues and prioritize them. To do this, an Issue Register can be created. In this register multiple fields can be presented. Generally, these fields consist of the name of the issue, description, priority, assumptions, qualitative impact, and quantitative impact, however other fields can be added to the issue register to adapt it to specific situations and different realities.

Name	Description	Priority	Assumptions	Qualitative impact	Quantitative impact
Wrong product delivered	Customer rejected product due to wrong delivery	2	1000 monthly deliveries with an error rate of 3%, each error costs on average 30 €	Disrupted schedules due to rework	1000 * 0.03 * 30 = 900 €
Late payment fees	Fees incurred as a result of invoices not being paid by the due date.	3	About 10% of invoices are paid late with a penalty of 5% Average normal cost is 200 € and 100 invoices per month	Poor reputation with suppliers	0.1 * 100 * 200 * 0.05 = 100 €

Table 2 – Example of an Issue Register
Source: Adapted from (Dumas et al., 2018)

The name of the issue should be concise and understandable by every participant, the description should also be short and focused on the issue and not the impact, the priority field represents the level of importance of the issue about others, assumptions are any data used in the estimation of the impact, qualitative impact describes the intangible impact that is difficult to quantify, and quantitative impact is an estimate of either time loss, revenue loss, avoidable costs, etc. (Schwegmann & Laske, 2010; Dumas et al., 2018)

Schwegmann & Laske (2010) defend that the issue register should be done at the same time as the as-is business process models in the discovery phase since during this phase, multiple issues will be raised and the registration of these issues can be a starting point, even though most of the time the issue register would be left incomplete.

The Pareto analysis follows the distribution of Vilfredo Pareto. The Pareto diagram is a graphical representation of issue prioritization (Conger, 2010). The principle of the Pareto analysis is that most issues are caused by the same small number of factors. It can take the issue register as inputs. Dumas et al. (2018) demonstrate a typical approach to Pareto analysis as:

1. Define the effect to be analyzed and the measure to quantify the effect.
2. Identify the issues that contribute to the effect.
3. Quantify each issue according to the chosen measure by using the quantitative impact column of the issue register.
4. Sort the issues from highest to lowest impact, according to the chosen measure.
5. Draw the Pareto chart, where each issue is represented by a bar, and a curve plots the cumulative percentage impact of the issue.

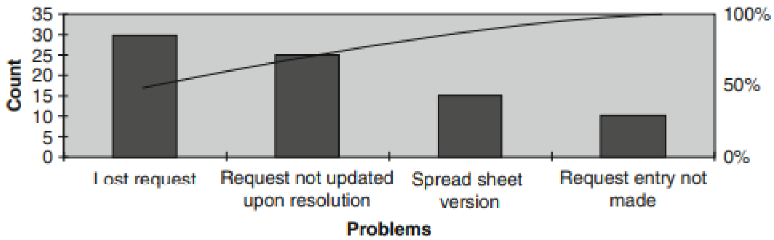


Figure 5 – Pareto Diagram
Source: (Conger, 2010)

2.2.3.2. Quantitative Analysis

Qualitative analysis can be complemented by several different quantitative analysis techniques. Where qualitative analysis can be useful to gather insights into a process, the results of these analyses alone cannot, most of the time, provide a solid base for decision making (Dumas et al., 2018). In the context of BPM, quantitative analysis is concerned with analyzing the conduction of the process and different performance measurements.

These performance measures can be defined in, typically, three dimensions: time, cost, and quality. (Van der Aalst, 2011), with a fourth dimension coming into play when considering the issue of change (Dumas, et al., 2018).

Van der Aalst (2011) also specifies performance indicators regarding each dimension. Regarding the time dimension, he identifies:

- Lead time (also called cycle time)
- Service time (also called processing time)
- Waiting time
- Synchronization time

Lead time represents the total time that it takes from the creation to the completion of one case. Service time is the time that resources are spent on the actual work. Waiting time represents the time a case is waiting for resources to become available, e.g., when the case is idle. Finally, synchronization time is the time an activity is waiting for an external trigger or from a parallel branch in order to synchronize different cases. It differs from waiting time in the sense that the activity is waiting for another activity or event and not for resources.

Regarding costs, Dumas et al. (2018) states that there are two main types of costs, fixed and variables costs. Where fixed costs are, in great part, not affected by the intensity of the process, due to being overhead costs, variable costs, on the other hand, are correlated with certain variables such as the level of sales and number of purchased supplies. Operational costs are substantially related to the costs of human resources. Van der Aalst (2011) states that one important key performance indicator in most processes is the average utilization of resources over a specific time period.

The quality dimension focuses mainly on the product or service. This dimension has several measurement possibilities, be it by customer satisfaction surveys and product or service defect rates. (Dumas et al., 2018). Quality can be seen by the products and service's reliability, performance, durability, and conformance to specifications (Prajogo & Sohal, 2006; Van der Aalst, 2011; Dumas et al., 2018). Dumas et al. (2018) also state that there is a distinction between external and internal quality. External quality is measured from the point of view of the client, whereas internal quality relates to the process participant's point of view. Often, these dimensions have direct relationships with each other.

Dumas et al. (2018) defines the fourth dimension, flexibility, as the degree to which a process is able to vary, measuring the flexibility of a process means to capture to what extent the performance of a process is affected or maintained when sudden changes occur. Like the other dimensions, flexibility can also be refined into a number of key performance indicators (KPIs), i.e., the level of capacity of a single resource to execute different tasks in the process, and the ability the degree of success of a process when handling changing workloads (Dumas, et al., 2018).

Flow analysis is a set of quantitative analysis techniques that enable the calculation regarding the time and cost dimensions if there is knowledge about the performance of the processes' activities. The calculations for this type of analysis are made by following a set of rules regarding the BPM model created in the discovery phase. Each activity is said to have a cost and time. Flow analysis is the calculation of all of those activities' times or costs considering the different decision points of the process. It allows for the calculation of cycle times, cycle time efficiency, WIP, and even process capacity, which is the maximum number of cases per time unit that can theoretically be managed. The simplest calculation possible is if a process is constituted only by activities, the calculation of the average cycle time is equal to the sum of each activity's time. The different gateways, such as exclusive and parallel gateways, pose different rules in the calculations. (Dumas et al., 2018; Laguna & Marklund, 2019).

Another and perhaps the most widely held method for qualitative process analysis is process simulation. This technique offers a certain degree of flexibility and can be done through computer-based models for the evaluation of certain process designs. Over the years, the computer's hardware and software power has been rising, allowing for a more effective computer-based simulation. Simulation helps in the verification, validation, and optimization of process models and designs. (Laguna & Marklund, 2019). "The main idea of simulation is to repeatedly run a model and thus collect statistics and confidence intervals" (Van der Aalst, 2011).

Van der Aalst (2011), however, discusses that even though simulation aims to improve the business processes, a lot of organizations misuse this technique by not paying enough attention to the integrity and correctness of the produced business process models, also stating that it makes no sense, and can be derogatory, to conduct simulation on models that assume idealized versions of the current and real process.

Certain information is necessary to be able to run computer-based business process simulations, the probability distribution for the processing time of each task, each task cost and added-value produced, the necessary resources to perform the task, the inter-arrival times and mean arrival rate, the starting date and time, and at least one of the following: the end date and time of the simulation, the real-time duration of the simulation, or the required number of process instances to be simulated (Dumas et al., 2018).

ABPMB (2013) lists a set of critical success factors, suggested practices, and pitfalls to avoid during the process analysis phase. These are in sum:

- Executive Leadership
- Organizational Process Maturity
- Avoiding the Solutions Design during Analysis
- Paralysis from Analysis
- Proper time and Resource Allocation
- Customer Focus
- Understand the Organizational Culture
- Consider Potential Resistance
- Carry Fact-Based Analysis

2.2.4. Process Redesign

Throughout the carried analysis, a lot of ideas and directions for redesign are found. This is where process redesign comes into play. The process redesign phase takes the created as-is business process models and the outputs of the analyses as inputs to enable a proposal of several approaches for business process optimization. Dumas et al. (2018) discuss that most organizations do not take the best approaches in this phase, "redesign is often not approached in a systematic way, but rather considered as a purely creative activity. The critical point with creative techniques is that parts of the spectrum of potential redesign options could be missed", suggesting that specific, suitable methods could be used to allow for better redesign decisions and options.

The basis of the term redesign is "any change to an existing process, be it minor or major", (Dumas et al., 2018). The output of this phase is a "to-be" business process model. This model encapsulates the studied improvement suggestions.

The concept of the "Devil's Quadrangle" derives from the difficult trade-offs between each performance measure dimension, e.g., the ideal redesign of a business process would enhance each dimension, reducing the time and cost and increasing the quality and flexibility. However, this situation does not really happen. What happens is when redesigning a process, improving one dimension will weaken at least one of the others. Reijers & Mansar (2005) present an example of adding reconciliation tasks to improve the quality of the service, having the drawback of affecting the cycle time of the process. They also state that awareness of these trade-offs is of great importance when redesigning processes, presenting a threat to the integrity of the processes.

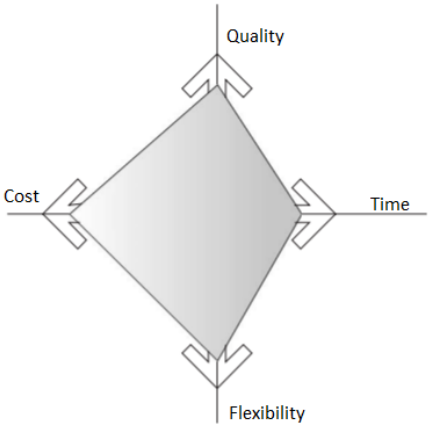


Figure 6 – Devil's Quadrangle
Source: Adapted from (Reijers & Mansar, 2005)

Dumas et al. (2018) defend that there are multiple process redesign methods, and each method falls in a particular category. Dumas et al. (2018) present an illustration of a redesign orbit delimiting each redesign method into having an ambition, be it transactional methods or transformational methods, nature, creative or analytical, and a perspective, inward-looking or outward-looking. This illustration can be seen in figure 7.

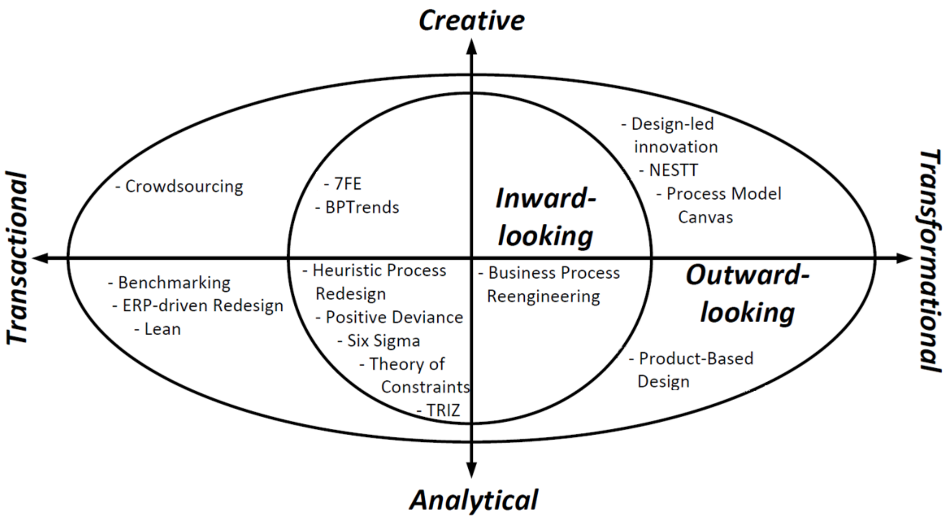


Figure 7 – The Redesign Orbit
Source: Dumas et al. (2018)

Transactional methods generally look at the issues in a process and aim to resolve them incrementally while not changing the current process structure. On the other side of the spectrum, transformational methods aim to reach breakthrough innovation while considering the fundamental core and principles of the current process structure.

Relating to the nature of the methods, these can be either analytical or creative. Analytical methods are characterized by a strong link to a mathematical basis and quantitative analysis and techniques. While creative methods rely upon the human creative power, building on the advantages of group dynamics.

Finally, when it comes to perspective, inward-looking methods are the ones that consider the process from the internal organization's perspective, focusing on defined objectives and performance measures. Outward-looking methods take the perspective from an outsider of the process, often in the form of a customer or supplier (Dumas et al., 2018).

The Heuristic Process Redesign uses a list of redesign heuristics to evaluate and identify possible improvements to the "as-is" business model. The different dimensions (time, cost, quality, and flexibility) have different heuristics that affect them directly. Some of these heuristics, which were mainly considered during the internship project, are as follows (Reijers & Mansar, 2005; Dumas et al., 2018):

- Time dimension
  - Parallelism - consists of putting tasks in parallel, which can reduce time.
  - Order-based work – removing batch-processing and periodic activities when possible.
- Cost dimension
  - Elimination – removing non-value adding activities and tasks from the process.
  - Empower – reducing middle management and giving process participants more authority and decision-making power.
- Quality dimension
  - Triage – applying either specialization or generalization of tasks as appropriate.
    - Specialization – dividing a general task into two or more alternative tasks.
    - Generalization – Integrating two or more alternative tasks into one general task.
- Flexibility dimension
  - Centralization – treating geographically dispersed resources as if they were centralized to be able to commit them in a more flexible way.

2.2.5. Process Implementation

The implementation phase of the BPM lifecycle encompasses different methods to transform the created conceptual process models into executable models. Dumas et al. (2018) suggest that the first step for process implementation is to identify each task's type, to either automated, manual, or user.

A user task is any task that the participant of a manual task can notify the system upon task completion using the worklist handler of the system. Review then the manual tasks to understand the possibilities of integration with the system, removing the elements that cannot be interpreted by the system. Then it is necessary to complete the process model by stating the relevant control-flows and data aspects for execution. All electronic data objects required as inputs and outputs by the tasks need to be specified. The next step is transforming the resulting model into one with a granularity level adequate for execution, e.g., tasks may be too abstract, needing decomposition, or too detailed, needing aggregation. Finally, specify the way each model element is implemented in the system. Some execution properties are variables, messages, data mappings, script tasks, etc.

An important note to take is that all of the implementations being taken cannot have a major disruption in the business's daily activities, and it is of great difficulty to have a large number of changes simultaneously.

2.2.6. Process Monitoring and Control

It is not the rule to have the implementations of the redesigned business process meeting the initial expectations. Here is where the phase of monitoring and control takes place. It is necessary to understand what is happening during process execution and evaluate the previously defined process performance measures. In other words, process monitoring and control focus on the gathering of insights about the performance of the process by aggregating the process metrics to Process Performance Indicators and Key Performance Indicators and revealing differences and variations between the “as-is” and “to-be” models. (Schmidt & Fleischmann, 2013)

The main business process monitoring techniques consist of statistics-based techniques (i.e., Performances Dashboards), and model-based techniques (i.e., Process Mining).

There are several types of dashboards, including operational, tactical, and strategic dashboards. Each dashboard aims at different levels of the organization. Operational process dashboards focus on the process workers and operational managers, having a weight on monitoring the work-in-process and resource loads. Tactical dashboards are targeted at process owners, with an emphasis on analysis of process performances, reviewing the cycle times and error rates. Strategic dashboards are aimed at the higher level in the organization (executives), providing statistical information about the link between the process performance and the strategic objectives. Most BPMS, CRM, and ERP systems offer the tools for the creation of these dashboards. (Dumas et al., 2018)

Process mining is another set of techniques for performance evaluation and analysis. It is based on event logs produced during the business process execution, allowing for a more in-depth comprehension of how the process is being executed with details down to a task level.

Dumas et al. (2018) list four use cases for process mining techniques classification:

- Automated process discovery
- Conformance checking
- Performance mining
- Variant analysis

Taymouri et al. (2021) explains that automated process discovery, as mentioned earlier in the discovery phase, takes event logs in order to produce business process models that match the behavior in those same event logs. Conformance checking compares a given process model with the event logs to give insights into the differences between the two. Performance mining also takes both the event logs and business process model to create an "enhanced process model", containing elements that help in search of issues, i.e., bottlenecks. The variant analysis takes two different event logs and compares them, presenting a list of their differences. In general, one of the event logs represents the positive cases, and the other represents the negative ones.

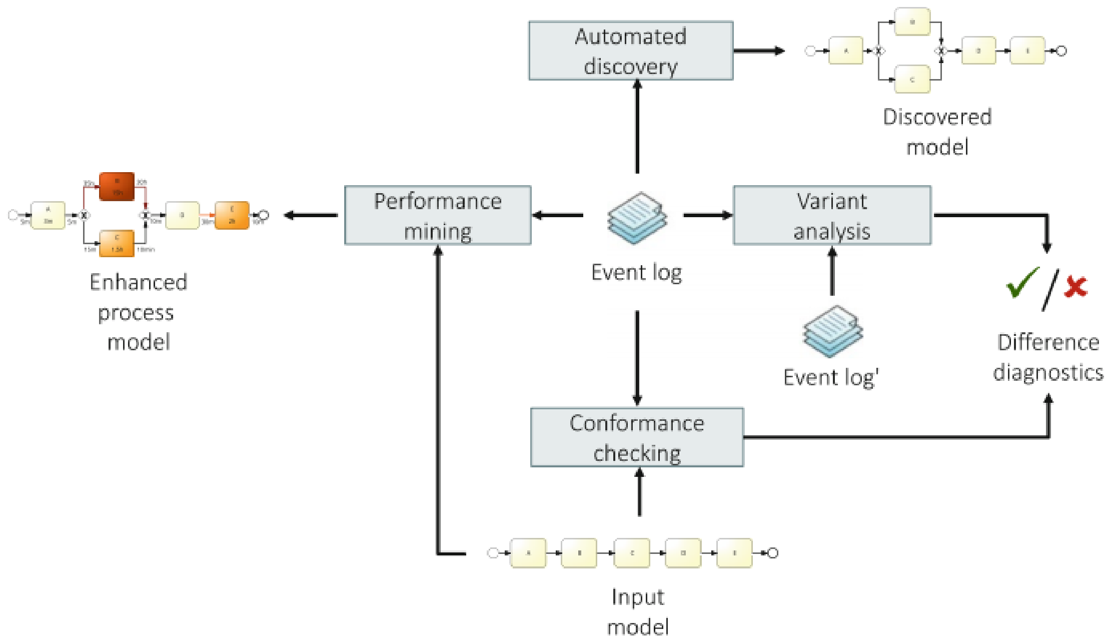


Figure 8 – Process Mining Techniques
Source: Dumas et al. (2018)

2.3. ENTERPRISE PROCESS MANAGEMENT

EPM is the holistic system resulting from multiple BPM projects inside an organization, providing a governance model for managing these initiatives and assuring the alignment between them and the organization's business strategies (ABPMP, 2013).

A framework that outlines the elements of BPM can become an essential tool for strategic challenges due to an allowance for task allocation priorities and timeliness of the progression of the several BPM elements (Brocke & Rosemann, 2015).

Brocke & Rosemann (2015) have listed six core elements that represent a critical success factor for BPM:

- Strategic alignment
- Governance
- Methods
- Information Technology
- People
- Culture

Since processes need to be designed and managed according to certain priorities and situations, strategic alignment represents the link between the organizational priorities and enterprise processes to maintain an effective improvement of its performance (Brocke & Rosemann, 2015). The governance of BPM establishes roles, responsibilities, and accountabilities for the levels of BPM. The methods used in the context of BPM need to be defined and coherent with the organization's reality and objectives. Information Technology is a significant enabler of BPM projects, being it on process analysis and also for process modeling and monitoring. A BPM project is also dependent on the people that apply it. These people need to continuously enhance and use their skills and knowledge to improve their business performance. Finally, culture represents the collective groups of people and has a high impact on BPM initiatives. Culture is about creating an acceptance of BPM in the organization's environment (Brocke & Rosemann, 2015).

Brocke & Rosemann (2015) also present a table demonstrating these core elements in the literature for further reading and review. This table can be seen in table 3.

Factor	Source
Strategic Alignment	Elzinga et al., 1995; Hammer, 2001; Hung, 2006; Jarrar et al., 2000; Pritchard and Armistead, 1999; Puah K.Y. and Tang K.H, 2000; Zairi, 1997; Zairi and Sinclair, 1995
Government	Braganza and Lambert, 2000; Gulledge and Sommer, 2002; Harmon, 2005; Jarrar et al., 2000; Pritchard and Armistead, 1999
Methods	Adesola and Baines, 2005; Harrington, 1991; Kettinger et al. 1997; Pritchard and Armistead, 1999; Zairi, 1997
Information Technology	Gulledge and Sommer, 2002; Hammer and Champy, 1993; McDaniel, 2001
People	Elzinga et al., 1995; Hung, 2006; Llewellyn and Armistead, 2000; Pritchard and Armistead, 1999; Zairi and Sinclair, 1995; Zairi, 1997
Culture	Elzinga et al., 1995; Llewellyn and Armistead, 2000; Pritchard and Armistead, 1999; Spanyi, 2003, Zairi, 1997; Zairi and Sinclair, 1995

Table 3 – BPM core elements in the literature
Source: Brocke & Rosemann (2015)

2.3.1. Business Process Governance

Business Process Governance (BPG) aims to create the structures, metrics, roles, and responsibilities to manage the performance of the business processes and the BPM projects. The need for governance comes from the existence of an organizational design. Spanyi (n.d.) states that there are three main reasons for companies to struggle in the execution of large BPM projects. Lack of a robust framework, lack of codification of management practices, and resistance to change from the participants and executives.

Bruin (2009) has identified capability areas for the multiple BPM core elements. These capability areas are shown in figure 9 below:

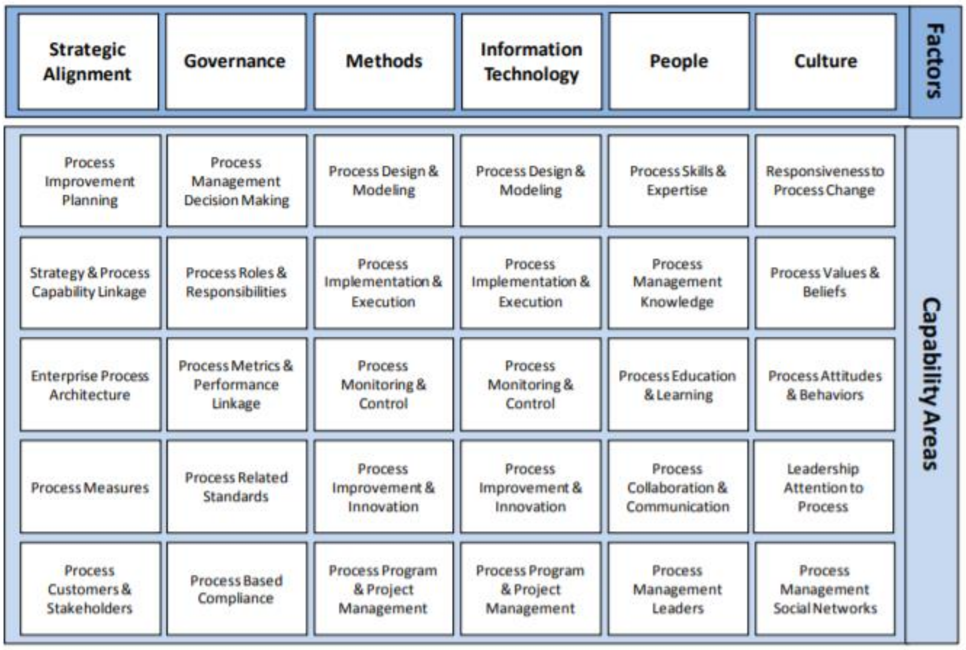


Figure 9 – BPM Capability Framework
Source: Bruin (2009)

ABPMP (2013) provides a shortlist of typical roles in BPG. The process manager who monitors the activities in the process, helping in the identification of issues and recommends improvement actions, the process change manager that has the role of presenting improvement measures and controlling the impact of changes, and the process consultant that are experts in the control of the process changes and its standards.

2.3.2. Maturity Model

A maturity model is a technique that aims to evaluate and measure different aspects of a process, or organization in general, consisting of some maturity levels (Becker et al., 2009). Proença & Borbinha (2016) state that this technique can provide organization:

- A measuring for auditing and benchmarking
- A measuring of process assessment against objectives
- An understanding of strengths, weaknesses, and opportunities

There have been multiple proposed BPM maturity models, Brocke & Rosemann (2015) have identified and listed some of these:

- Process Condition Model

- Strategic Alignment Maturity Model
- BPR Maturity Model
- Harmon's BPM Maturity Model
- Rummler-Brache Group's Process Maturity Model
- OMG's Business Process Maturity Model
- Rosemann and de Bruin's Maturity Model
- Capability Maturity Model Integration (CMMI)
- Hammer's BPM Maturity Model (Process Audit)

Despite the existence of several proposed maturity models, this paper will have only an overview of CMMI, which serves as a base for several other maturity models, being in the nomenclature and different maturity levels, Rosemann and de Bruin's Maturity Model (BPMMM), and the Object Management Group Maturity Model (BPMMOMG).

2.3.2.1. Capability Maturity Model Integrated

CMMI comes from a first version, the Capability Maturity Model (CMM). This capability model was developed by the Software Engineering Institute, with the goal of optimizing software processes for the US Ministry of Defense. However, the application of this model presented several challenges for organizations due to the inability to serve different departments with the same maturity model, limiting improvements due to the necessity of different maturity models having to be used. CMMI is a direct evolution of the CMM. This new integrated model aims to optimize whole business processes (Butzer et al., 2017).

The Capability Maturity Model Integration (CMMI), as presented in Chrissis et al. (2011), differentiates five levels of maturity:

1. Initial
2. Managed
3. Defined
4. Quantitatively managed
5. Optimizing

Applying the CMMI to BPM, Dumas et al. (2018) explain that in the first level of maturity, BPM is said to be either nonexistent or minimal and uncoordinated. At the second level, organizations have an increased awareness of BPM, allowing for a capitalization of it, where the management gets more involved with the initiative. However, the expertise is still external to the company. The "defined" level represents a situation where the organization collects the perks of the first BPM projects, and the use of BPM tools, methods, and techniques becomes more refined. At the "quantitatively managed" level, the BPM projects focus on the later stages of the lifecycle. At this level, the organization usually does not rely on external proficiency. Finally, in the last level, "optimizing", BPM is established in integrity, be it in the operational and strategic levels. BPM tools are the norm, being broadly accepted.

2.3.2.2. BPMMOMG

Regarding BPMMOMG, the model can be mapped to CMMI; however, it is written aiming to guide business process improvement initiatives with better characterization as workflows across the whole organizational level, instead of the bounded project orientation of CMMI (Weber et al., 2008).

Similar to other maturity models, the BPMMOMG is also divided into five maturity levels. Each level represents the state that the organization is in regarding process capability and transformation adaptability. Each stage, except level 1, has different process areas' goals. In order for an organization to reach the next level, all of the goals assigned to the previous stage need to be fulfilled. Weber et al. (2018) represented each of these stages as:

1. Level 1: Initial – at this level, there is a high level of inconsistency on the practice and results of processes inside the organization. Each process is regularly not defined, standardized, and documented. Assignments are performed through individualized methods and the organizational environment is not friendly in process implementation.
2. Level 2: Managed – at this level, there are already basic planning and management processes being integrated with the organization. However, these processes consist mainly of the essentials to develop and support the products and services. This level presents 9 process areas, e.g., Organizational Process Leadership (OPL), that has the goal of establishing the executive accountability for the management of the process improvement activities, and Work Unit Performance (WUP), which aims to establish work agreements between the individuals and the work unit manager in order to reach the agreed results.
3. Level 3: Standardized – development, preparation, operation, and supporting processes are already documented and available for use across the organization at this level. There is an exploitation of best practices during the standardization of its processes. There is a deep focus on an integrated approach to the processes from the previous level of individual work units approach. At this level, the organization also presents a more adapted version of standards and process descriptions to fit its characteristics. Therefore the processes can be viewed as

more consistent but showing a set of differences for unique needs. Regarding BPM, at this stage, organizations show signals of growing their BPM capabilities. Level 3 of maturity contains ten different process areas, e.g., Organizational Process Management (OPM), which develops standard processes and process assets and deploys them for use, improving based on their strengths and weaknesses, and Product and Service Work Management (PSWM), that aims to manage the work for a product or service utilizing the already defined processes.

4. Level 4: Predictable – This level of maturity is focused on reducing and controlling the variation in the way the work is being performed in the organization while aiming to predict the performance and results that will be achieved. Furthermore, organizations perform corrective actions regarding their processes to enable a reach for quality goals. Level 4 of maturity contains five process areas, e.g., Organizational Common Asset Management (OCAM), that aims to identify the common characteristics between the organization's current and future products and services, to improve the performance. And Product and Service Process Integration (PSPI), that has the goal of improving the efficiency of independent work by linking the work processes of the different roles involved in the product or service.
5. Level 5: Innovating – An organization at this final maturity level presents an understanding of its critical business issues and responds to these same issues by supporting different quantitative improvement initiatives. Gaps identified in the current performance are tackled and filled, defects and problems are analyzed by different work units, and corrective and preventive actions are undertaken to avoid future pitfalls and recurring types of defects. This maturity level presents six process areas, e.g., Organizational Improvement Planning (OIP), that aims to establish quantitative improvement goals in the organization, as well as an infrastructure to carry out improvements. Defect and Problem Prevention (DPP), has the goal to identify different causes of defects that block the work unit's plans to be achieved and present stop recurring issues. (Weber et al., 2008).

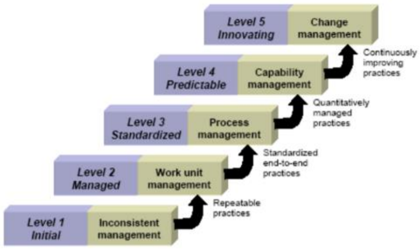


Figure 10 – BPMMOMG
Source: Weber et al. (2008).

2.3.2.3. BPMMM

De Bruin and Rosemann (2007) state that there are two separate types of business process maturity models, those that assess the maturity of specific business processes separately and those that assess the organization's capability in adapting BPM initiatives. With this into consideration, de Bruin and Rosemann (2005) proposed a business process management maturity model that extends from previous maturity models by addressing the different complexities with a holistic view and focusing on the organization's maturity to undertake BPM initiatives and not only assessing it's business processes maturity. The proposed model is multi-dimensional in the sense that is composed of several components, these being: factors, stages, and scope, where the scope is further divided into organizational entity and time. There is a further combination between coverage and proficiency, where the coverage represents the width of use of BPM practices across the organization or entity being assessed, and proficiency representing the perceived quality of those practices (Rosemann and de Bruin, 2004).

De Bruin and Rosemann (2005) state that the proposed model contains two different assumptions, the first being that the factors, represented by the BPM critical success factors, can be seen as the independent variables, where the dependent variable is the success of the BPM initiative, the second assumption being that if an organization has high maturity in each presented factor, there is a direct reflection on the possible level of success in the proposed BPM initiative.

The factor dimension, as explained by de Bruin and Rosemann (2005), has the purpose of both enabling the organization to design and deploy BPM strategies to improve its BPM success and also to enable correlation analysis between those factors and improving the comprehension of possible BPM issues.

Each stage of maturity, being Initial, Defined, Repeatable, Managed, and Optimized, represents a pre-defined maturity stage and is used to represent and quantify the evolution of each factor or item on a defined scale.

The organizational entity is the unit that is being analyzed, e.g., a department. It is an important component due to the allowance for an internal comparison between entities that enables the implementation to be adapted and specific strategies.

Finally, the time represents the point in time that the model is being applied. It is helpful to understand the current position and to assess the progress of that application over time.

Rosemann and de Bruin (2004) list three criteria to measure both coverage and proficiency of BPM within the organization, these are:

Coverage:

1. The number of processes in BPM practices.
2. Staff involvement in BPM practices.
3. Links to other management tools

Proficiency:

1. Response to BPM initiatives.
2. Frequency of conducting BPM activities.
3. Suitability of BPM tools and practices.

These criteria then receive a five-point grade scale for each maturity stage.

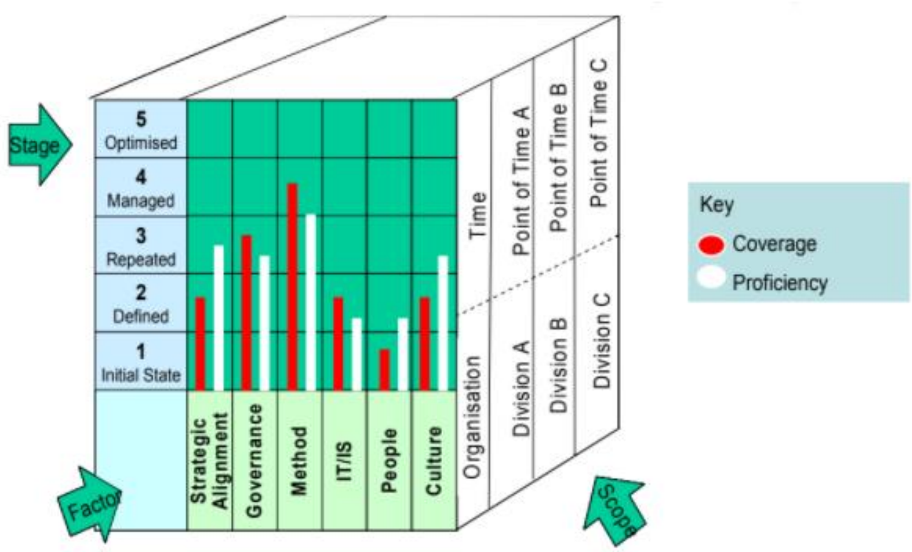


Figure 11 – Rosemann and de Bruin's BPMMM
Source: Rosemann and de Bruin (2005)

The nomenclature of each stage is consistent with those of CMM. This decision was made due to their previous acceptance of them. Each maturity stage description varies depending on the considered factor. However, the definition of each stage of maturity to each factor is based on incorporating the six criteria above, using quantifiable indicators to ensure comparability of stages (Rosemann and de Bruin, 2004).

2.3.3. BPM Context Framework

Proposed by vom Brocke, Zelt, and Schmiedel (2015), the business process management context framework consists of a framework that allows for the assessment of an organization characteristics and factors in order to describe a BPM project, enabling the organization to have a better understanding of itself and of the project, and with that, aligning the project to the organization. (vom Brocke & Mendling, 2018)

The framework is divided into four different dimensions, assessing the goal, process, organization, and environment. Each dimension represents a contextual factor, and the goal dimension tackles what the organization wants to achieve when implementing a BPM project. In the context of BPM, goals can be either exploitation or exploration. Exploitation BPM approaches aims to take advantage of already implemented and established tools and management approaches to increase the process efficiency. In contrast, exploration approaches have a focus on innovative processes through different creative techniques (vom Brocke, Zelt, & Schmiedel, 2015).

BPM initiatives need to be adapted to the type of process that is receiving it, vom Brocke, Zelt, and Schmiedel (2015) list several process characteristics that influence the effectiveness of these initiatives, such as the process's value contribution (core, management, or support processes), the repetitiveness of the process, its knowledge intensity, degree of creativity, interdependence between the processes and the process variability.

The organizations themselves also present a set of characteristic processes that can cross organizational boundaries. Therefore it is necessary to assess their scope of being either inter or intra-organizational. The organizational size also provides an essential role in this assessment. Different sized organizations have different levels of depth in their processes, e.g., larger organizations might present processes that need more standardization and formalization than small organizations. (vom Brocke, Zelt & Schhmiedel, 2015). Another essential characteristic is the type of industry being assessed since it is not guaranteed that each BPM practice is equally effective through either product or service-oriented organizations. Vom Brocke, Zelt, and Schmiedel (2015) also state that a BPM approach is more likely to succeed if the correct cultural values are in place. These can be having customer orientation, teamwork, and high degrees of responsibility. Finally, organizational resources present an essential aspect when applying a BPM initiative due to the need to allocate resources such as investments in information technology.

The last dimension mentioned by the authors is the environment dimension. This dimension handles the level of competitiveness and uncertainty in the surrounding environments of the organization.

2.3.4. City of Ghent – Case Study Overview

This case study, covered by Van Looy & Rotthier (2018), focuses on applying a BPM approach to a public-sector organization in the city of Ghent, Belgium. The identified issue of the organization was that the different departments had a "silo" mentality, in the sense that the different chains, namely, the taxes, environment, and civic affairs, all required separate customer profiles. The City of Ghent already had previously implemented web forms, all developed by the same IT supplier. However, their use was lower than the ideal, with around forty digital tax submissions per year. Some web forms were also browser-dependent, which resulted in several customer complaints. Even if the forms were processes from the web, their handling in the back office was entirely manual. The City of Ghent also had some downloadable forms that required the customers to download, print, and physically deliver them.

Previously the City of Ghent already had some digital initiatives, namely, featuring intuitive search functionalities, integrating more advanced search functionality, and basing the website on Search Engine Optimization, allowing customers to reach the desired forms directly from a search engine, such as Google.

After a first analysis, the BPM team had identified a set of needs. Some were a need for a more customer-oriented and uniform way of working, the need to have a higher return of investment (ROI) from the IT projects, and reuse of digital investments. The BPM consisted of two project managers, a business process manager, and an IT project manager that would work closely with each other. The business project manager would then work as a link between the departments undergoing the transformation and the organization that offers the technical support, considering the interest of the whole organization to counter the silo effects.

There were, however, some constraints for the project, high privacy concerns relating to governmental regulations, a limited budget, requirements that stated that physical process channels would still need to exist, independently of the desired digital channels, the services and processes had little to no degrees of freedom due to specified legislation, the type of services and customers were very heterogeneous (around 300 products and very different profiles of customer), and there was an intrinsic historic of working in silos.

A set of objectives were defined to fulfill the needs mentioned previously. This was to standardize the way to authenticate the users, enable electronic signatures, and provide information and forms regarding the e-services online through any browser and device.

The initial plan was to have a focus on both physical and digital service deliveries. This would include integration with both the City's external partners and through its departments. This case study can be situated through the typical lifecycle of a business process management initiative. For the process identification, process analysis, and process redesign phases, models of the core business processes using BPMN were created, allowing for a better visual representation of their instances. The main analysis techniques followed the principles of Lean, specifically waste analysis. As mentioned previously in the literature review, these analyses provided a higher understanding of the issues and aimed at reducing, and if possible, eliminating waste through the process. For the process implementation stage, it was decided to use a service-oriented architecture for the reuse of service components and also to create a common architecture.

This case study demonstrates a link between different BPM core elements, e.g., the strategic alignment can be associated with the focus on a digitization vision that focuses on a taken advantage of a more efficient set of processes based on top-down coordination and planning.

The initial perception of this initiative what that of a job-threatening one, employees were afraid of these likely changes, and how they would negatively affect their work. However, due to sound change management, their minds were slowly changed to have an understanding of how IT could help make their workloads easier to handle. Since there was still a reglementary need to maintain the physical alternatives, this resistance was also countered to some extent.

A BPM maturity assessment was made some years back. However, it was discontinued due to high costs and different process visions, focusing on entire process portfolios instead of specific processes. With this BPM initiative, the City intended to relaunch this assessment and idea of process-oriented working methods.

After the BPM team had an overview of the existing processes and their steps, they created fifteen different principles to which they named “building blocks”. These building blocks consist of what a public service may include as well as its maximum possible requirements. They are considered generic components to be shared across business processes. By sharing these generic components, their technological reuse is incentivized. These building blocks can be seen in figure 12 below. Some examples of these building blocks are as such:

1. Digital signature – both customer and employees present the need to electronically sign documents and validate those same signatures by verifying if the document received by the customer corresponds to the one sent by the employee.
2. Form Generator – a unique form generator to be used across any form type. Upon login to the City’s application, the customer should be able to check their personal information prefilled in the digital form. By building forms using different technologies, multiple links would be needed per technology. By creating a single form generator, it is only needed a single technological link to the application.

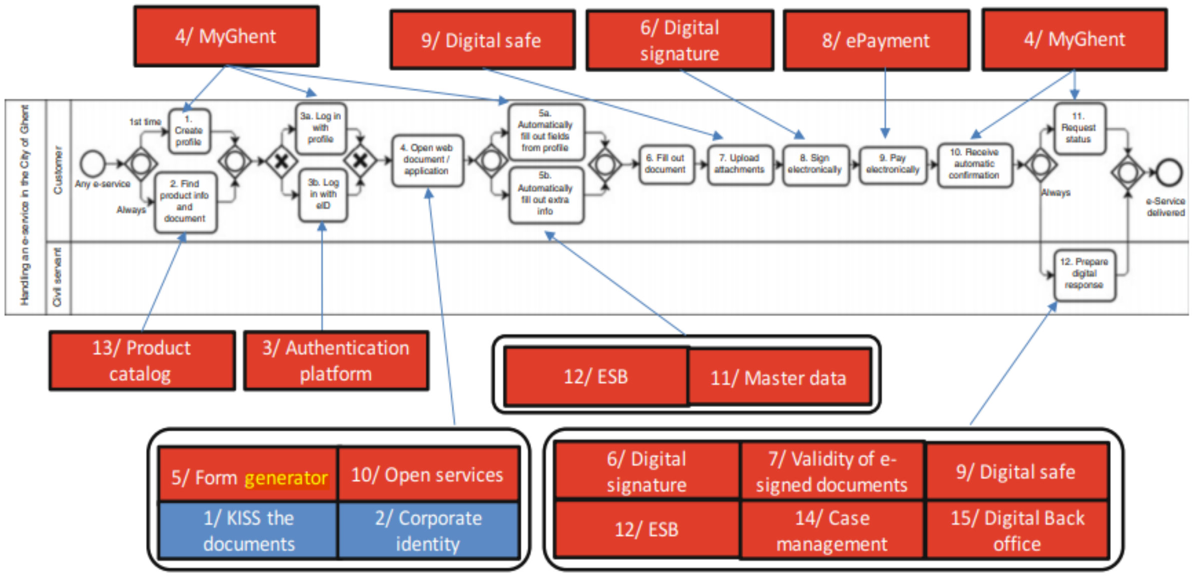


Figure 12 – City of Ghent Building Blocks
Source: Van Looy & Rotthier (2018)

As a result of this approach to digitizing processes, the number of digital tax submissions and digital subsidy requests increased immediately after the actions were taken. Digital submission rose from 5.5% to 28.9%, and digital proposals from 2.6% to 35.5% of the total. The views for optimization that was in line with the Lean thinking enabled a streamlined environmental digital chain due to the elimination of unnecessary components and steps. The access to management reports derived from the digitalization approach would also allow for useful insights that support future decision-making.

The implementation of digital signatures made employees not waste time and resources moving to the alderman and city secretary to sign each response letter. These time savings allowed that each customer could get the information if they get the requested subsidy, increasing customer satisfaction.

Based on several pilot results, the City aims to continue investing in the digitization of its services by taking advantage of these reusable components in the digital chains. The overall idea was to invest in the development a single time and avail too many areas in a maximum way.

The case study closes with five different lessons learned that may benefit both other public organizations and even private organizations, these being:

1. Align with external partners semantically

The City aligned its product catalog semantically with the Flemish government. With this availability of open data and a shared catalog for public services was created, allowing for an open-data source that customers and governments can use to find updated catalogs of services.

2. Be pragmatic instead of dogmatic

Taking a more pragmatic view can avoid new types of waste. Unnecessary bureaucracy can become arduous, and having a more practical approach can reduce time wastes. The example given by the author in this case study is that some simple documents, e.g., an online feedback sheet concerning simple questions, had specific procedure norms. To avoid superfluous procedures for each document, the City decided to create document types with respective established uniform procedures.

3. Assist Departments

The departments in the City lacked BPM knowledge and experience, being uncomfortable to reconsider their routines. They were then assisted by a centralized competence center, which changed the perception of employees to a positive one, resulting in good employee satisfaction survey results.

4. Be open to temporary workarounds to achieve quick wins

The implementation of the building blocks was considerably complex. Since this change could have a big impact on the way things were done, a simpler first version was launched as a temporary workaround.

5. Switch from silos to a single profile per customer

Customers send, several times, requests to change their information, such as the telephone number or e-mail address. With multiple profiles that chance could be done to only one of those profiles, leaving other departments with outdated data. A single profile also removes the need to handle multiple names and passwords that customers had to remember for the different services and departments. With this change, the customer expectations can more easily be met. This lesson can be translated to "create a single point of contact for customer".

3. METHODOLOGY

In order to achieve the established objectives, the work was structured according to the BPM methodology suggested by Dumas et al. (2018), which is mentioned in the literature review. The main phases of the said methodology with direct implementation on the internship project are Process Identification, Process Discovery, Process Analysis, and Process Redesign. The Process Implementation and Process Monitoring and Control phases are outside of the project's scope due to time constraints. However, even though there is not going to be a direct implementation of the process redesigns, there is still going to be a suggestion of actions to improve the implementation process in case the company wants to continue the project after the internship time is over.

This section presents what tools and techniques are going to be used during the internship project. A practical comparison of modeling software and modeling notation is going to be presented.

3.1. INTERNSHIP SETTING

The internship took place in the Azorean archipelago of Portugal. The company is located in multiple islands of the archipelago, including Terceira island and São Miguel island. During the internship, multiple trips between these two islands took place. Different process participants are on different islands, so to have closer contact to conduct interviews and observe daily activities, these trips were necessary.

As mentioned in the literature review, there are multiple methods for data collection in order to develop the business process models. Due to not all workers of the company sharing the same workspace, and even island, workshops were out of the scope. Therefore the main methods were evidence-based discovery, by reviewing documentation, observation of activities, and direct interviews with process participants. Techniques for the analysis of the created business process models fall in the category of the ones that were previously mentioned in the literature review, from qualitative analysis techniques, such as Value-added analysis, root-analyses, issue register, and Pareto analysis, and quantitative analysis as flow analysis and simulation.

3.2. METRICS

During the internship, multiple business processes models were developed, such as Technical Assistance, external IT project development, Document and Records control, among others. However, the BPM initiative, with further analysis and redesign, will be applied to the Technical Assistance process, the reasons for this decision will be presented in the process identification phase.

The main variables to be measured and analyzed are foreseen to be the cycle time, cost, and error rate of the process.

3.3. Choosing the BPM Modeling Tool

To be able to develop the business process models, it was necessary to decide which of the available tools for the matter was the most adequate. For this exercise, a handful of tools were considered. It is important to have in mind that this work was conducted in a company that did not have any previous contact with the matter at hand. Therefore one of the main concerns was to choose one tool that provided an easy-to-use and understand approach to business process modeling since multiple business models were created and are meant to be kept in the company even past the internship conclusion. Hence multiple tools were considered. These were Bizagi Modeler, Bonita BPM, Oracle BPM Studio, and Visual Paradigm.

Bizagi Modeler is one tool of a set of three offered by Bizagi, the other two being Bizagi Studio and Bizagi Automation. Bizagi Modeler focuses on the ease of use due to an intuitive drag-and-drop approach, presenting a freemium business model with free access to an adequate range of capabilities. Bizagi Modeler also provides a simulation view that allows for the quantitative analysis of simulation, and therefore, to a more in-depth comprehension of different metrics, with simulated cycle times and resource utilization. Moreover, it possible to import and export to interoperable formats, including XDPL, allowing for integration with other BPMSs. Bizagi also offers a cloud service to store different created models. (Bizagi, 2021).

Bonita BPM is an open-source BPM and workflow suite, enables the user to make graphical changes to business processes with BPMN, supporting XPDL. It contains three major design tools, being the whiteboard and the UI designer, the whiteboard is used to model the process and define its details, the Development menu that is used to create data models, and the UI designer always for the creation of application pages. Bonita contains several features, including refactoring, which is changing the name of a process element without changing the external behavior (Bonita, 2021).

Oracle BPM Studio is one of the components of Oracle BPM Suite that allows for business process modeling and the creation of process-based applications. Oracle BPM Studio shares the user interface with many other Oracle products. The process editor enables to model by simply dragging and dropping the elements. The simulation capabilities of this tool allow for the definition of multiple models for a given process, e.g., multiple “What-if” scenarios, and to run multiple processes simulations to learn how working in different processes can affect resources. (Oracle, 2021)

Visual Paradigm is a tool more focused on modeling using UML (Unified Modeling Language), with recent additions to support BPMN. It has a user-friendly interface, and it is of easy use. This tool also supports simulation. However, as noted by Pereira & Freitas (2019) its capabilities are still fairly low, since data inputs for simulation were limited, and it did not allow to assign a work cost to a resource. Its accessibility is also lacking due to only providing free access to the tool for a 30-day trial.

In the end, the Bizagi Modeler was chosen due to its accessibility, features, and some previous knowledge using the tool.

3.4. BPMN 2.0 Notation

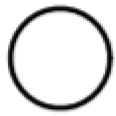
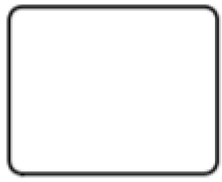
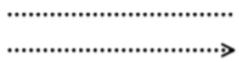
Business Process Modelling Notation is a standard notation for the creation of business process models, inheriting elements from previous notation such as XML Process Definition Language (XPDL), and the Activity Diagrams from the Unified Modelling Language (UML) (Dijkman et al., 2008). Developed by the Object Management Group (OMG), it has the goal of providing a readily understandable notation, ranging knowledge levels from business analysts to technical developers and executives. BPMN establishes a way to link both the business process design to the process implementation (OMG, 2013).

OMG (2013) lists five basic categories of BPMN elements:

- Flow Objects
- Data
- Connecting Objects
- Swimlanes
- Artifacts

Flow objects represent the elements that define the behavior of the business process, these are constituted by Events, Activities, and Gateways. There are 4 elements in the data categories, being Data objects, Data inputs, Data outputs, and Datastores. Flow objects can connect with each other, and other information by the Connecting Objects, this being Sequence Flows, Message Flows, and Association. It is with the Swimlanes that the modeling elements are grouped, this can be done using Pools and Lanes. Finally, Artifacts provide extra information about the process, the current artifacts include Group and text Annotation. Table 4 presents the basic elements of BPMN.

Category	Element	Description	Notation

Flow Objects	Event	An event is an occasion that triggers or has an impact on something. There are 3 types of events: Start, Intermediate, and End	
	Activity	An activity is a work done by some actor during the process. There are 2 types of activity: Sub-Process and Task.	
	Gateway	A gateway is used to control sequence flows, they determine branchings, forkings, etc. There are multiple types of gateways, where the most basic are the exclusive (X-OR) gateways, inclusive (OR) gateways, and parallel (AND) gateways.	
Connecting Objects	Sequence flow	A sequence flow is used to illustrate the order in which activities are performed	
	Message flow	A message flow is used to show the flow of messages between different participants. They connect the different pools.	
	Association	An association represents the link between the Artifacts of a process with the activities in which they are handled.	
Swimlanes	Pool	A pool represents the participant in the process.	
	Lane	A lane is a sub-partition within a pool, normally used to represent different internal participants inside the same pool.	

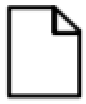
Artifacts	Data Object	A data object is a piece of information that serves as input or output of a certain activity.	
	Group	A group does not affect the sequence flow, it groups the elements by some established category.	
	Text Annotation	A text notation is used to provide extra information to a reader of the model	

Table 4 – BPMN basic elements
Source: Adapted from (OMG, 2013)

4. RESULTS AND DISCUSSION

Multiple meetings with the company's senior management were carried out before the start of the internship. During these meetings, there was a first discussion about the company's current issues, strategic objectives, and future plans. These discussions allowed for a better understanding of the company's settings and position in the Azorean environment. SISDIAS is a private company that focuses on services regarding the public sector of the Azores, more specifically on the accounting services and information technology implementation of the Azorean parishes throughout all nine islands, operating in most of their parishes. At the start of the internship, it was operating in about one hundred out of the one hundred and fifty-five total parishes of the region.

4.1. SISDIAS's BPM Maturity Assessment

The maturity, from a BPM point of view, relates to the point of development and capability of the organization of adopting a successful BPM initiative. (Weber et al., 2008)

The assessment of the company's BPM maturity was conducted using the BPM OMG maturity model. As previously mentioned, this model is divided into 5 maturity levels: Initial, Managed, Standardized, Predictable, Innovating, where each level, expect the first one, has several process areas associated with it (Weber et al., 2008).

To fulfill the first level of maturity (Initial), it is necessary to observe individual efforts without explicit organizational support. Organizations at this level are seen as the ones that have not yet reach the other levels of maturity. SISDIAS has demonstrated efforts regarding process improvement. Therefore it can be considered to have reached the initial level.

The second level of maturity (managed), is composed of 9 process areas, where the organization needs to achieve the goals of all process areas in order to achieve this stage of maturity level. These maturity levels are as follows:

1. Organizational process leadership
2. Organizational business governance
3. Work unit requirements management
4. Work unit planning and commitment
5. Work unit monitoring and control
6. Work unit performance
7. Work unit configuration management
8. Sourcing management

9. Process and product assurance

Organizational process leadership relates to the establishment of executive sponsorship and accountability for the organization's process improvement activities, i.e., the executive management needs to clearly define, justify, describe, fund, review and coordinate improvement initiatives in the organization (Weber et al., 2008). This process area can be seen as accomplished due to the several process improvement initiatives sponsored by the senior management.

Organizational business governance has the focus on executive accountability for the performance of the organization's work and results. Similar to organizational process leadership, there is a need for well-established work and management practices, business goals, and outcome measures. (Weber et al., 2008).

Work unit requirements management is related to the existence of documented and agreed requirements for the work to be performed in each work unit (Weber et al., 2008). This process area is at fault inside SISDIAS since there were no updated work procedures, having a lack of work management for each process participant. Subsequently, other process areas related to the work unit requirements management were also at fault, such as work unit planning and commitment, work unit monitoring and control, work unit performance, and work unit configuration management, even though some of these process areas are at different levels of completion, none could be considered as fully achieved, e.g., there are documented plans for work in different processes of the organization. However, these plans are not present in all processes and cannot be considered as fully consistent. SISDIAS has not achieved the work unit monitoring and control process area, this area focuses on the measurement and monitorization of work assignments for the individuals and workgroups in the work unit, keeping performance and results in line with the requirements, even though SISDAS has an established system for work assignments there are not clearly defined performance measures throughout the processes, and corrective actions are mainly performed based on customer complaints.

The sourcing management process area focuses on managing the acquisition of products and services from external suppliers (Weber et al., 2008). This process area is well accomplished by SISDIAS. There are multiple commitments with suppliers to provide the necessary products and services for each work unit, SISDIAS also has a list of trustworthy suppliers with preventive actions in place in case any issues arise. However, due to the small Azorean environment there are occasions where the supplier number is low, creating sets of problems for both SISDIAS and it's clients.

Finally, the last process area of this stage is the process and product assurance, which aims to provide conformance guidance and objectively review the activities of work efforts in the organization to ensure they conform with laws, regulations, and standards (Weber et al., 2008). SISDIAS has had process auditing initiatives, however, these are not systematic. The organization is in the middle of creating and implementation of a quality management system, which, if well adopted, could improve its maturity regarding the organization's processes and BPM maturity.

After analyzing the nine process areas of the second level of maturity, it is possible to conclude that the organization has not yet fully achieved this maturity level, there is still a lot of room for improvement, being it in the processes themselves as well as the efforts for manage and apply these improvements. Since a level of maturity of the BPM OMG maturity model needs to be fully achieved to move to the upper levels, there was no analysis regarding the process areas of levels 3, 4, and 5.

An assessment of the SISDIAS's characteristics and factors was performed to describe the proposed BPM initiative aiding with its development, alignment with the organization, and implementation.

The focus of the organization regarding the BPM project is of an exploration-oriented nature. SISDIAS does not have enough established tools and management approaches in order to exploit them (exploitation-oriented). Therefore it is necessary to innovate the processes through creative techniques.

Regarding the process dimension, SISDIAS aims to improve a core process this initiative firstly, this process is of repetitive nature with a low to medium knowledge intensity. This classification was given due to the process not needing a large transfer of knowledge between process participants but needing a degree of human judgment. The process is classified as of low creativity due to the structured way of working not allowing for many creative decisions during its lifecycle. The Technical Assistance process is of medium interdependence due to its need of having clear communication and hand-offs between the different process participants and it is also of low variability.

The scope of the project is on an intra-organizational process due to it taking place within the boundaries of the organization. The BPM initiative is to be applied to a Product and Service industry. However, even though SISDIAS sells different products, their main focus is on the service provision aspect. SISDIAS is a small company with a culture of medium support for BPM projects, this support derives mainly from the awareness of the need for improvement. However some resistance to necessary change is noticeable. SISDIAS has a medium number of organizational resources for a BPM project implementation since a focus on internal changes is enabled by the low competitive environment experienced by the organization. Lastly, there is a low environment uncertainty, meaning that conditions within the business environment are, for the most part, fairly stable.

Dimension	**Contextual factor**	**Characteristics of SISDIAS**
Goal	Focus	Exploration
Process	Value contribution	Core process
	Repetitiveness	Repetitive
	Knowledge intensity	Low to medium knowledge intensity
	Creativity	Low creativity
	Interdependence	Medium interdependence
	Variability	Low variability
Organization	Scope	Intra-organizational processes
	Industry	Product and Service Industry
	Size	Small organization
	Culture	Medium supportive of BPM
	Resources	Medium organizational resources
Environment	Competitiveness	Low to medium competitive environment
	Uncertainty	Low environmental uncertainty

Table 5 – SISDIAS's BPM Context Framework
Source – Made by the author

4.2. Process Identification

Upon arrival at the company, the first task was to review existing documents with specifications of the undertaken processes inside the company. This process area is well accomplished by SISDIAS,

These documents, however, were fairly outdated since they were developed more than a decade ago, even presenting processes that were entirely removed from the works of the company.

To compensate for these outdated materials, several meetings were had with the executive management, and different process participants, which can be identified in table 6 below, to understand exactly what was and wasn't correct in the available documentation.

Actor	Description	Amount
Senior Management/Director	Has the role of overseeing operations, flow of work, and strategic decisions implementations	1
Administrative Assistant	Works directly with both clients, employees, and senior management to carry out sales, proposal elaborations, and technical assistance requests.	2
Technician	Answers to technical assistance requests presented by the administrative assistant to aid clients.	3
Programmer	Belongs to the programming team, having the role to develop internal and/or external IT projects.	3
Accountant	Accountants with the role of working with external clients.	8
Head of Accountants	The person who is mainly responsible for the overall provided accounting services.	1
Head of Technicians	The person who is mainly responsible for the technical assistance services.	1
Customer	Clients who pay for products or services provided by the company.	--
Supplier	The ones who deliver the necessary products when necessary or provide outsourced services.	--

Table 6 – Process Participants
Source – Made by the author

The identified processes were inserted in table 7, where the columns of this table consist of the name given to the process, a brief description of each process, as well as a classification of the process type, between core, support, and management processes.

Process	**Description**	**Type**
Technical Assistance	Assistance is given to a client, being it in the form of technological device maintenance and repair, software installation, and accounting orders.	Core
Commercial Prospection	The process is carried out upon identification of a product sale or service, to increase the opportunity chance to be successful.	Core

Sales proposal creation	Creation of the proposal for the product sale or service to deliver to the client, gathering all the necessary components of said sale.	Core
Sales	Process of completing the transaction, either of the product, set of products, or service.	Core
Post-sale	Process related to the activities and procedures to be taken to maintain a relationship with the client to which a sale or service was previously provided.	Core
Internal IT project	IT projects developed for internal purposes, i.e., SISDIAS's website, internal document control platform.	Support
External IT project	IT projects developed for external clients, i.e., parishes websites.	Core
External Training	Training provided to clients, i.e., upon software installation.	Core
Internal Training	Training provided to employees, i.e., software training to accountants, training to improve process understanding and efficiency.	Support
Complaints Handling	Related to the Technical Assistance process, complaints handling focuses on providing the clients with the resolution to possible complaints.	Core
Infrastructure and Equipment Maintenance	Maintenance of the company's infrastructures and equipment to maintain fluid business continuity.	Support
Outsourcing	Contracting outsourced services, i.e., outsourcing the installation of software not familiar to the internal employees.	Support
Purchasing	Purchasing of the necessary materials.	Support
Human Resources	Process for handling internal actors and stakeholders.	Support
Recruitment	Process of recruiting employees, as necessary.	Support
Performance Evaluation	Evaluation of the current performance of the different employees and suppliers.	Support
Corrective and Preventive Actions	Actions taken to discover, investigate and correct non-conformities related to the products, services, and processes.	Management

Employee Payments	Process to complete employees' monthly payments.	Support
Accounts Payable	Process of paying owed money to the suppliers.	Support
Accounts Receivable	Process of enforcing claims for payments for the products and services provided.	Support
Accounting and Finance	Holistic process of recording and processing financial transactions of the company.	Support
Storage	Movement of goods into appropriate storage spaces.	Support
Logistics	Execution of efficient transportation from point of origin to the point of consumption, while meeting customer requirements.	Support
Quality Management	Set of procedures followed to maintain organizational quality targets.	Management
Strategic Management	Process for defining the organization's global strategy sets, with the goal of achieving increased performance rates.	Management
Supplier Relationship Management	Planning and execution of different interactions with the suppliers.	Management
Document Control	Management of how documents are approved, updated and delivered.	Management

Table 7 – SISDIAS's processes
Source – Made by the author

Since it would be non-effective in terms of cost and time to apply a BPM approach to each of the identified processes, it was necessary to prioritize them. The first idea was to focus mainly on a set of core processes since these have an increased impact on how the organization works, being the main way that it generates income. The Sales, Technical Assistance, and External IT projects processes were, at first glance, equally considered. It was necessary then to analyze them in terms of importance, health, and feasibility. Table X provides a brief comparison between the processes relative to their prioritization criteria.

Process	**Importance**	**Health**	**Feasibility**
Sales	Of great importance, however, the company focuses itself more on providing	The healthiest of the three processes, the sales process does not present as many	The most complex process inside the company due to being directly related to many other processes,

	services than on selling products.	issues on its flow as the others.	such as post-sale, purchasing, and proposal creation.
Technical Assistance	The main gateway for income of the organization.	Presented some issues, ranging from coordination between process actors to on-time deliveries.	Somewhat complex process due to different variations and end products of the process.
External IT Projects	The least impactful process of the three due to the relatively low number of orders of the type.	The most recent of the three processes in the organization presents high volatility and a high degree of possible change.	Highest feasibility in receiving a BPM approach due to its malleability.

Table 8 – Process prioritization
Source – Made by the author

Upon analyzing the above processes it was concluded that due to its importance and health issues the Technical Assistance process would be the one receiving the BPM approach inside the organization. This approach would try to combat the existing issues in the process having into consideration its importance to the company, it was anticipated that the complexity of the process could bring limitations for future changes implementations since this process is the one involving the major number of process participants, between accountants, technicians, and administrative assistants.

With the identified processes a process relationship map was created, this map consists of a diagram showcasing the relationships between the processes of the organization. The processes in the diagram are divided according to their process type (core, support, and management), as well as grouped by close relationship, i.e., the sales process is grouped within the post-sale, proposal elaboration, and commercial prospection processes since they are closely related and can be considered to work together, in the sense that the process of sales received direct inputs from the proposal elaboration. To be able to create an adequate process relationship map it was necessary to meet with the different process participants, enquiring them to clarify each process boundary and different connections. The output of this exercise can be seen in the figure 13 below.

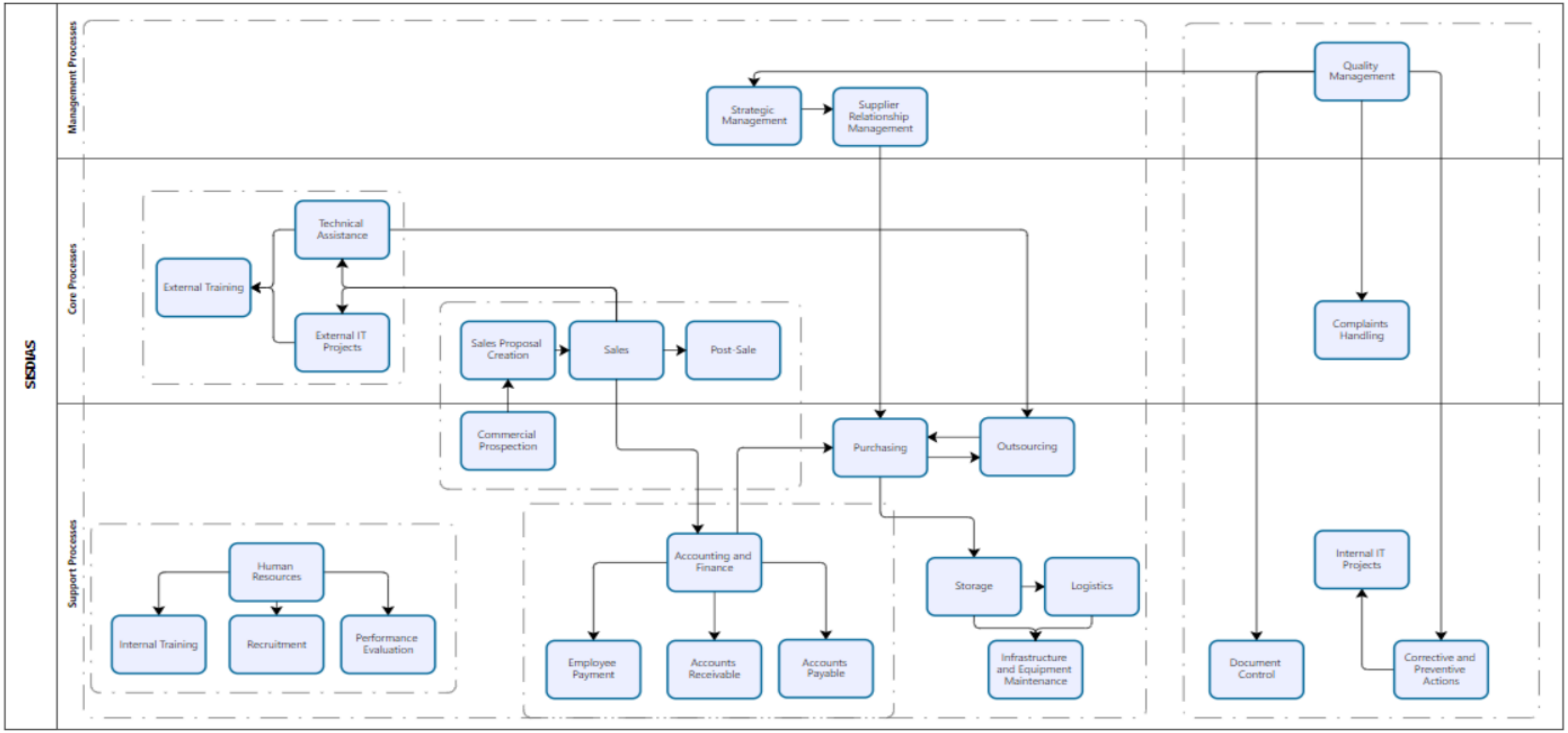


Figure 13 – SISDIAS's processes map
Source – Made by the author

As it can be seen the company presents a fairly complex process relationship map, showcasing multiple core processes, meaning that, the company has multiple ways to generate income, being it from providing external training, developing external IT projects, providing technical assistance, and complaint handling when necessary, to the sale and elaboration of proposals of products.

Some initial metrics were defined for the Technical Assistance process. These metrics aimed to tackle different dimensions of the process. Regarding the customer perspective, it was necessary to take into consideration the level of customer satisfaction, in terms of an intern process efficiency perspective, the cycle time, in the time dimension, was an important one to consider, being one of the biggest problems posed by the senior management upon deliberation.

4.3. Process Discovery

As mentioned in the literature review of this internship report, the process discovery stage can be subdivided into four different steps. Which the first is defining the setting, which consists in creating a BPM team made of business analysts and domain experts. Since the company never carried out a project of this nature, it did not have any current business analysts, and BPM experts, working with it, therefore, for this project, the author represented the only business analyst for this team in terms of domain experts the main participants in the process were the administrative assistants, which were the ones who had the first direct contact with the client, the technicians, which were the ones who actually performed the needed work through the technical assistance services, and the senior management who had an understanding of the process by overseeing it.

The steps are taken to gather the necessary information in order to be able to understand and model the technical assistance process consisted mainly of document analysis, observation, and interviews with the process actors. Chronologically the first step was the document analysis. This decision was made due to several factors, such as having an initial understanding of how the organization perceives its processes, research and analyze how the documentation inside the organization was stored and distributed, and also due to a limitation at the internship start where direct interviews and process observation was not initially possible. Since the first point of contact with the processes flows were made by document analysis, there were a few instances where, upon meeting with the senior management and process actors, it was noticeable that they were somewhat out of date, containing obsolete activity descriptions and referring to documents and files that no longer existed, i.e., the documents did not account for situations where the work to be done by the technicians were of maintenance, or of such a small degree that the technician would only spend a few minutes in it, not needing any further registration and any payment fees.

Upon arriving physically at the facilities, observation discovery and interview-based discovery were allowed to be conducted. Multiple instances of observation analysis were carried out to confirm the findings made in the document analysis and try to understand if any major process activities, steps, and points of the decision were missing. During these observations, the process followed a standard flow. However, due to the current COVID-19 situation, all of them were services provided remotely, not allowing for a complete understanding of the situations where it would be necessary to move to the client's current location. Therefore it was necessary to complement this limitation with interviews with the process participants, enquiring them to how the process would be carried out after that point. The interviews were held mainly with two of the administrative assistants, one technician, and senior management. When they were conducted, the focus was to create the final AS-IS models. Therefore it was necessary to understand and identify the process boundaries, activities, events, resources, handovers, control flows, and any additional elements.

Defining the process boundaries, meaning what happens to trigger the start and end of the process, raised some initial challenges, where in the documents it was defined that the process should start as the client contacted the company, showcasing a need, after interviews with the process participants it was concluded that this was not entirely the case and that the process started as soon as an internal participant would identify the need of a client, i.e., the technical assistance process could be trigger either by the clients themselves contacting the company, but also by an employee (administrative assistant, technician, or senior management) considering that something was missing, or needing to be handled. Regarding the end of the process, it was noted that depending on the size of the work to be done. The process could end upon archiving the PIT (technical intervention process), a document which is opened at the initial activities of the process, where several types of information are registered, in the cases where it is identified that the needed amount of work is small the process ends immediately after performing the quick service, without the need for payment and registration.

With the process boundaries defined, it was necessary to identify the different activities, intermediate events, and process gateways during the process flow, as well as the responsible entities. These were identified as follows:

Number	**Node**	**Type**	**Resource**
1	Need identified	Start event	
2	Analyze need	Activity	Administrative Assistant
3	Is it a small work?	Exclusive gateway	
4	Send information to technician	Activity (Handover)	Administrative Assistant
5	Receive information	Activity	Technician
6	Analyze Service	Activity	Technician
7	Do work	Activity	Technician
8	Confirm work with client	Activity	Technician

9	Problems with service?	Exclusive gateway	
10	Work done	End event	
11	Open PIT	Activity	Administrative Assistant
12	PIT	Data Object	
13	Send information to Technician	Activity	Administrative Assistant
14	Receive information	Activity	Technician
15	Analyze requirements	Activity	Technician
16	Contact client	Activity	Technician
17	Schedule service	Activity	Technician
18	Is it remote service?	Exclusive gateway	
19	Go to the agreed location	Activity	Technician
20	Analyze needed materials	Activity	Technician
21	Are there needed materials?	Exclusive gateway	
22	Gather material prices	Activity	Technician
23	Present prices to the client	Activity	Technician
24	Does the client accept prices?	Exclusive gateway	
25	Verify stock	Activity	Technician
26	Is it available in stock?	Exclusive gateway	
27	Does the client make materials available	Exclusive gateway	
28	Receive materials from client	Activity (Receive)	Technician
29	Organize materials	Activity	Technician
30	Send purchase request to purchasing department	Activity (Send)	Technician
31	Receive materials	Activity (Receive)	Technician
32	Take materials	Activity	Technician
33	Perform agreed service	Activity	Technician
34	Test service	Activity	Technician
35	Service error	Intermediate error event	
36	Register errors	Activity	Technician

37	Evaluate change in service	Activity	Technician
38	Error register	Data object	
39	Fill in the service report	Activity	Technician
40	Digitize report	Activity	Technician
41	Send report to administrative assistant	Activity	Technician
42	Service report file	Data object	
43	Receive report from technician	Activity	Administrative Assistant
44	Is work finished?	Exclusive gateway	
45	Close PIT	Activity	Administrative Assistant
46	---	Parallel gateway	
47	Import files to cloud in PIT in analysis	Activity	Administrative Assistant
48	Archive records in paper	Activity	Administrative Assistant
49	PIT closed	End event	
50	Fill in worked already done	Activity	Administrative Assistant
51	Import files to the cloud	Activity	Administrative Assistant
52	Cloud SISDIAS (MEO)	Data store	
53		Intermediate message event	

Table 9 – Technical Assistance process activities, gateways, events, and data objects
Source – Made by the author

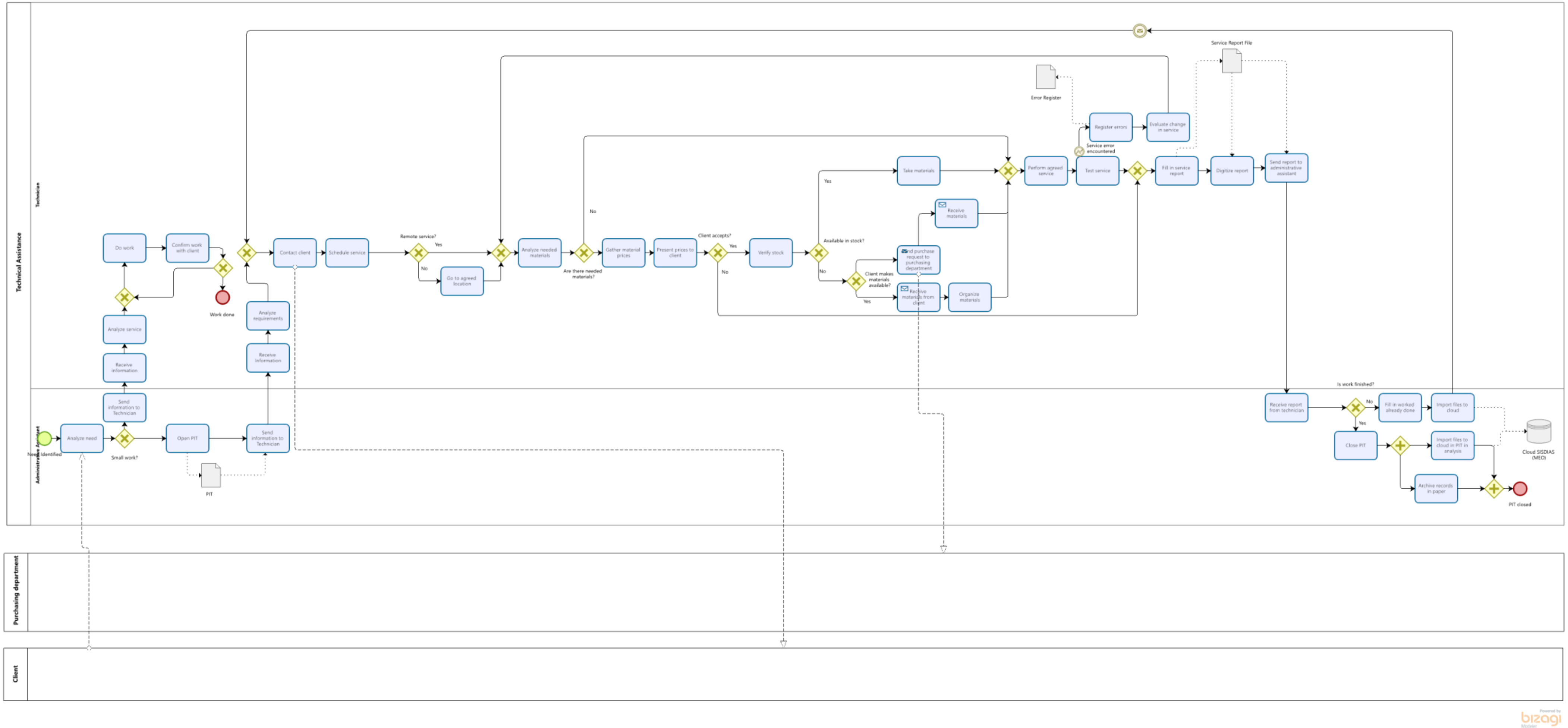


Figure 14 – Issue-to-resolution As-Is process model
Source – Made by the author

The above process represents the AS-IS model for the Technical Assistance process. One pool with two lanes was created to represent the activities handled by the administrative assistant and the ones handled by the technician. Another two black box pools were created to represent both the purchasing department as well as the client.

The process starts with the identification of a client's need (1). As mentioned previously, this need can be presented directly by the client or proposed by an internal actor. The administrative assistant will then roughly analyze the identified need (2), with the client, giving it a classification of either small and quick work or if it is a more time-consuming service (3).

In the case of being a small amount of needed work, which generally occurs less frequently, the administrative assistant forwards the needed information to the technician (4), which upon receiving it (5), analyzes what it is needed to do (6), performs the work (7), and confirms if everything meets the client's requirements (8), if something is wrong or missing the work has to be redone (9), however, if everything is along with the client's requirements the process ends (10).

When it is considered that the work requires more time, a PIT is opened (11), filled in with the gathered information, and that information is then forwarded by the administrative assistant to the technician (13), which when finished analyzing the requirements (14,15), contacts the client (16) and immediately schedules the technical intervention (17). Different types of service will require the physical presence of the technician, works such as the in-house installation of software, or reparation of hardware. However, some works are remote, especially for the past months due to the COVID-19 situation, the company has avoided unnecessary physical services (18). In the cases of physical services, the technician needs to go to the agreed location (19). He then analyzes what materials are necessary (20), if any (21), gathering the total cost of materials (22), and presenting that cost to the client (23), in the case that the client accepts the proposed budget (24), the technician then verifies the items on stock (25), taking any materials available (32). There are cases where the clients themselves can make the materials available (27) if any are missing, which in that case the technician receives the materials from the client (28) and organizes them (29), if both the stock is not available and the client does not make the materials available the technician needs to send a purchase request to the purchasing department of the company (30), receiving them at a later time (31). When all the materials are gathered, the technician can now perform the agreed service (33). Upon completion of the service, the technician also needs to test if the service meets the customer requirements (34). If any error occurs (35), they have to be registered (36) in the error register (38), the technician then addresses what needs to be altered in the service (37), and a rework is done. When the service meets the agreed requirements, the technician fills the service report (39), digitizes it (40), and forwards it to the administrative assistant (41).

The administrative assistant receives the report (43), and enquires the technician if any work was left to be done (44), due to either lack of necessary materials or time. If anything was left to be done the administrative assistant fills what was already completed (50), and imports the file to the cloud (51, 52), where posteriorly a technician can pick up the work again (53). When the work is successfully completed, the administrative assistant closes the PIT (45), and simultaneously imports the files to the cloud in a folder for eventual analysis (47), and archives the records in a paper (48), ending the process (49).

To validate the model syntactically, e.g., if it complies with the BPMN notation syntax, the inbuilt model validation of Bizagi Modeler was used. This validation helps to clarify any mistakes when designing the process. However, it has limitations, focusing mainly on misconnections of nodes, and simple rules. Therefore it was necessary to also manually analyze the structure of the model to understand if any mistakes were made. To assure the semantic quality of the model, several interviews with the domain experts were held, during which the pragmatic quality of the model was also discussed, verifying if the model was reader-friendly for each of the process actors. Observation of the process flow, compared to the completed process model, was also carried out to analyze if there were problems in the model. During this exercise, multiple changes were applied to the model.

4.4. Process Analysis

In this chapter, it is presented the multiple analysis conducted regarding the Technical Assistance process. The chapter starts with the qualitative analysis (Value-added analysis, Waste analysis, Issue register, Pareto analysis) and after it handles the quantitative analysis (Flow analysis and Simulation).

4.4.1. Value-added Analysis

This analysis aims to classify each process step regarding the customer's perspective of value addition throughout the standard process flow. Each overall process activity is decomposed into several steps.

Technical Assistance		
Activity	**Performer**	**Classification**
Identify need	Administrative Assistant	VA
Analyze need	Administrative Assistant	BVA
Register order and client information	Administrative Assistant	NVA

Compare order to previously completed orders	Administrative Assistant	NVA
Access e-mail	Administrative Assistant	NVA
Chose available technician	Administrative Assistant	NVA
Send information to the technician	Administrative Assistant	BVA
Access e-mail	Technician	NVA
Receive information	Technician	BVA
Analyze service requirements	Technician	BVA
Register requirement's notes	Technician	NVA
Access needed software	Technician	BVA
Perform service	Technician	VA
Contact client	Technician	BVA
Test service	Technician	VA
Confirm service with the client	Technician	BVA
Access email	Technician	NVA
Send e-mail to Administrative Assistant	Technician	NVA
Get PIT	Administrative Assistant	BVA
Fill PIT	Administrative Assistant	BVA
Access e-mail	Administrative Assistant	NVA
Send e-mail to Technician	Administrative Assistant	NVA
Access e-mail	Technician	NVA
Receive information	Technician	BVA
Analyze service requirements	Technician	VA
Register requirement's notes	Technician	NVA
Verify client's contact	Technician	BVA
Contact client	Technician	BVA
Schedule service	Technician	VA
Verify if remote service	Technician	BVA

Verify the location of the service	Technician	BVA
Confirm means of transportation	Technician	BVA
Move to site	Technician	VA
Analyze problem with the client	Technician	VA
Analyze necessary materials	Technician	VA
List materials	Technician	BVA
Verify material prices	Technician	BVA
Get the total sum of costs	Technician	BVA
Prepare document of prices	Technician	BVA
Present prices to the client	Technician	VA
Get client’s approval	Technician	VA
Verify stock	Technician	VA
Get materials from stock	Technician	VA
Transport materials to the site	Technician	VA
Ask if the client provides materials	Technician	BVA
Get client’s response	Technician	BVA
Receive materials from client	Technician	VA
Analyze materials	Technician	BVA
Organize materials	Technician	BVA
Access email	Technician	NVA
Send purchase order to purchasing department	Technician	BVA
Await a response from purchasing department	Technician	NVA
Receive a response from purchasing department	Technician	BVA
Receive materials	Technician	VA
Perform the agreed service	Technician	VA
Test service	Technician	VA
Analyze results of tests	Technician	VA

Register errors	Technician	BVA
Evaluate possible changes in service	Technician	BVA
Fill service report	Technician	BVA
Connect to printer	Technician	NVA
Digitalize report	Technician	NVA
Access e-mail	Technician	NVA
Forward report to Administrative Assistant	Technician	NVA
Access e-mail	Administrative Assistant	NVA
Receive report from technician	Administrative Assistant	NVA
Fill in work done	Administrative Assistant	BVA
Access company's cloud	Administrative Assistant	BVA
Import file to company's cloud	Administrative Assistant	BVA
Close PIT	Administrative Assistant	BVA
Import files to cloud "PIT in analysis" folder	Administrative Assistant	BVA
Connect to printer	Administrative Assistant	NVA
Print PIT	Administrative Assistant	NVA
Go to archives	Administrative Assistant	BVA
Archive in paper	Administrative Assistant	BVA

Table 10 – Technical Assistance Value-added analysis
Source – Made by the author

Since a VA step can be seen as any step that increases the direct satisfaction of a customer, steps such as the scheduling of the service and the performance of the service itself are classified as VA. BVA steps are those which do not add to the customer's satisfaction, nonetheless they are necessary to conduct the process. Therefore steps such as verifying which type of work is to be done and filling the necessary documentation are considered as BVA steps. Finally, NVA steps are those that do not fit in the previous categories. These steps do not add value to the customer and should be eliminated from the process since they can be seen as waste, manual registrations, and unnecessary message submissions are examples of such steps. This analysis will be of great importance in the redesign stage of the BPM approach. In this stage NVA steps are aimed to be removed and BVA steps are aimed to be either eliminated or reduced.

4.4.2. Waste Analysis

The waste analysis focuses on the negative side of the process, trying to find various types of waste throughout its lifecycle.

Technical Assistance		
Waste Category	Type of Waste	Activity
Move	Transportation	Move to archives
	Transportation	Move to printer
	Transportation	Move to warehouse for stock verification
	Transportation	Transport materials from warehouse to service site
	Motion	Looking for data and information in the PIT and service reports
	Motion	Printer in a different room from employees from accounting services
Hold	Inventory	Archiving physical files
	Waiting	Wait to receive materials
	Waiting	Wait for the client's approval response
	Waiting	Wait for the connection to the printer
Overdo	Defect	An encounter of a service error
	Defect	Error in service due to incapacity of technician
	Defect	Mistake in service requirements inputs
	Defect	Necessary rework of service
	Defect	Wrong materials purchased due to error in analysis of service
	Overproduction	Opening a PIT before finalizing the deal with the client
	Overproduction	Purchase order with extra unnecessary materials
	Overprocessing	Duplicate data needed in PIT and service report

Table 11 – Technical Assistance Waste analysis
Source – Made by the author

There are multiple possible identified wastes, as seen above, throughout the process. These wastes need to be eliminated or reduced in order to bring efficiency to the process. A prioritization of waste elimination can be created to focus specifically on the most damaging ones, e.g., unnecessary rework due to avoidable defects on the service can be considered as of higher importance of elimination than less frequent and harmful wastes, i.e., waiting for waste of connection to the printer.

4.4.3. Cause-effect Diagram

In order to produce a cause-effect diagram, it is necessary to clearly identify and define the existing problem statement. One of the problems identified that occurs throughout the technical assistance process is the lack of process efficiency. Therefore the center, or effect, of the diagram is defined as "Lack of process efficiency".

The second step is to define the causal categories of the diagram. These were defined as, People, Procedure, Technology, Organization, Material, and Environment. These categories were chosen firstly by looking at sets of standard categories and then adding and removing several that were seen as unfit for the problem statement.

Several primary causes of the problem were identified and categorized accordingly for each categorical cause. These primary causes were identified in brainstorming sessions with the senior management and several process actors.

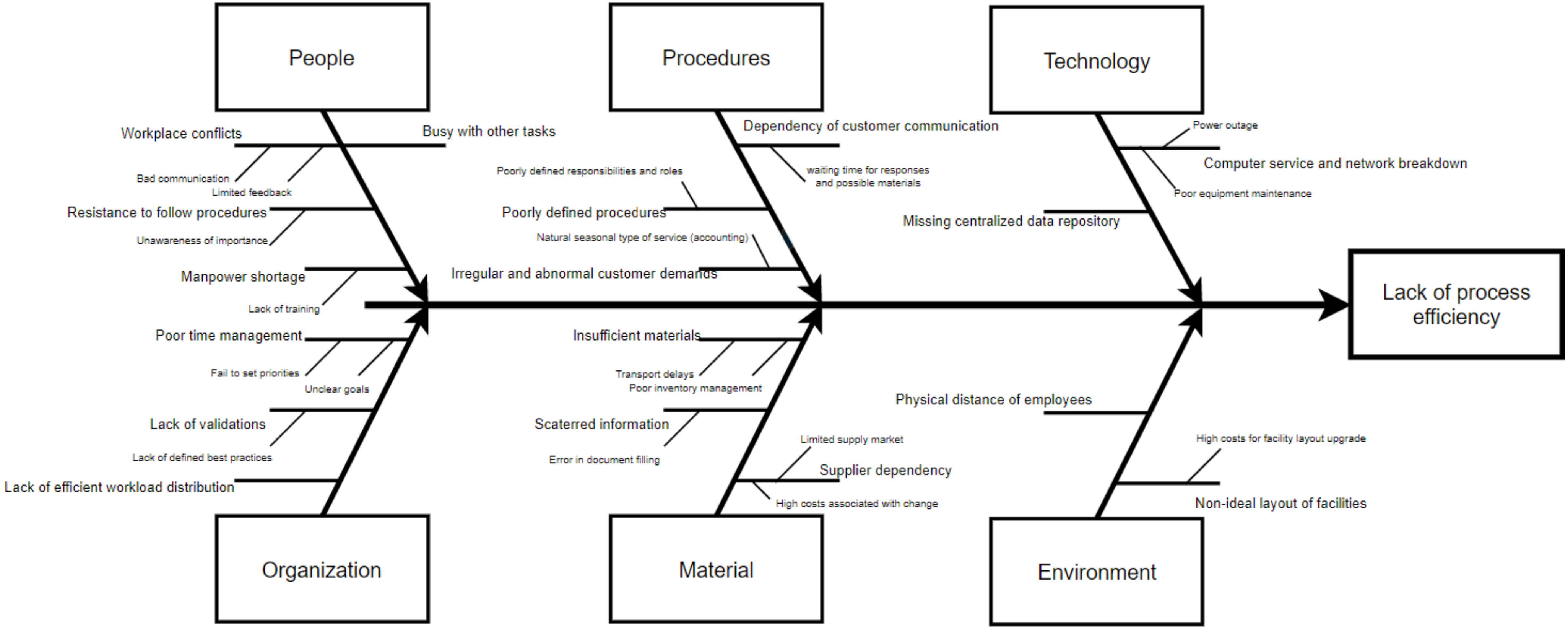


Figure 15 – Cause-effect diagram
Source – Made by the author

They were primarily for the people (human error) category, the existence of workplace conflicts, the current resistance to follow the defined procedures, cases of manpower shortage, and situations where the employee is overworked with tasks of lower priority. A further exercise was to figure some sub details regarding each primary cause. There were cases where this exercise was possible, such as the cause for workplace conflicts was thought to be caused by instances of poor communication in the organization, as well as moments of limited feedback, primarily by the senior management, but also between different processes participants. If there is an unawareness, by process participants, of the importance of following defined procedures, there will be resistance to such following. There are also several instances where the shortage of manpower can be linked to the lack of training and knowledge by some participants. When the service can be seen as complex, a shorter number of participants can resolve them; therefore, if multiple more complex services are happening simultaneously, this lack of training is more apparent.

When analyzing the organization category, it was identified that the primary causes relating to it were the existence of relatively poor time management by the participants, lack of validations, and also inefficient workload distribution in the organization. The poor time management can be connected to several unclear goals, and a failure to define priorities (which correlates as well with the "busy with other tasks" cause in the People category)

Regarding the material category, it can be seen that there are instances where, when the technician needs them, the necessary materials are not available, which causes delays in the provision of the service, this lack of materials can be caused by a large number of factors, where the main ones were identified to be due to transport delays and a possible poor inventory management practice. Information can also be considered as materials for this organization; therefore, the disorganization and misplacement of the necessary information can affect the process efficiency. The organization is rather dependent on its suppliers. This is caused by a limited supply market in the small Azorean environment, as well as the high costs associated with the changes of the supplier.

It is important to have well-defined procedures, this can result in a better understanding by the process participants, which would also lead to less rework, faster process cycle times, and possibly less utilization of resources, these procedures, however, can only be created if the responsibilities and roles of each participant are firstly well defined and established. There are instances where the customer demand is irregular and abnormal, this can impact the flow of the process and perception by the participants. The organization is not only dependent on suppliers, but also on their customers, since this technical assistance process is highly dependent on customers, on response times, but also on the cases where the customer is the one providing the materials for the assistance, this dependency can severely affect the flow of the process, and therefore, its efficiency.

For the technology category, it was noted that computer service and network breakdowns could cause these issues in the process, problems such as poor equipment maintenance and power outages are examples of causes for these breakdowns, it was also identified that a centralized data repository was missing inside the organization, where multiple participants could get the information that they needed to complete each service.

Finally, regarding the environment category, it was identified that the layout of the desks in the facility could be considered as non-ideal due to the time needed to be taken to move from one place to another, and since the organizations work as one, in multiple islands, this physical distance between the employees could also be seen as hurting for smooth and efficient communication and efficiency.

4.4.4. Why-why Diagram

For the why-why diagram exercise, the question of "Why is this process inefficient" was posed, the inputs for this diagram came directly from the cause-effect diagram previously constructed, the highest priority causes were then asked the question "why?" multiple times until a root cause was identified for each.

This exercise was also performed by multiple participants, including senior management. For the cause of poorly defined procedures, it was agreed that these procedures were not well defined due to a lack of understanding of strategic goals, mainly by the process participants, no one in the company has any knowledge about efficient process flow development and analysis, which can cause some confusion and issues while developing said standardized procedures, to attain this knowledge it is also necessary to invest either in training or contracting a specialist in the area who could guide the company through the treatment of its processes.

Another reason for inefficient processes is the multiple workplace conflicts. These conflicts are generated mainly due to poor communication between the process participants. In order to improve communication, it is necessary to increase employee engagement. This engagement can be considered low due to multiple factors, such as the physical distance seen between them, unbalanced workload distribution, and a lack of available tools either to complete the necessary services or even to communicate between them. The main reason why these tools are missing comes down to the lack of knowledge from either the participants and the senior management as to what tools to use adequately.

There are multiple instances where data is wrongly entered, be it on the PITs or the accounting software. This happens mainly due to the disorganization of the information management inside the organization, where employees have, sometimes, a hard time locating the information needed. Information can also be found with duplicate entries, which can confuse and misguide the participants. This scattered information can be traced to the existence of data silos between departments and software due to the inability of the used software to communicate with each other and interchange data, which leads to data needing to be entered multiple times. This state occurs due to costs associated with software migration as well as the missing knowledge of software adoption.

Finally, the last cause identified was the common workforce shortage during the workload distribution of service provision. This shortage can be traced to the unbalance in participant knowledge and ability falling again the category of not enough training provided due to its associated costs.

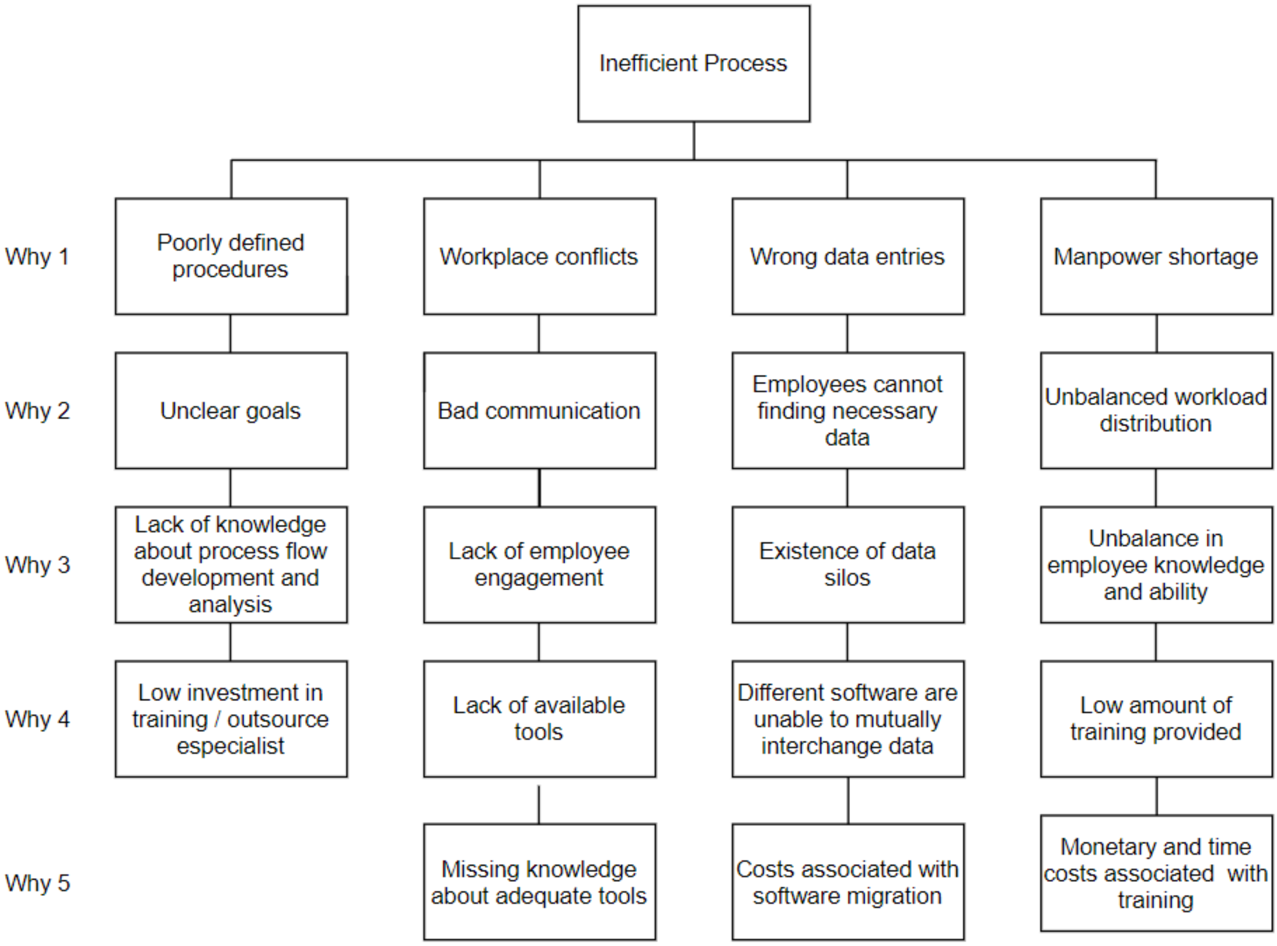


Figure 16 – Why-why diagram
Source – Made by the author

4.4.5. Issue Register and Pareto Analysis

In a period of two months, multiple issues were registered during the process of technical assistance. Seventy-five total issues were registered. It is important to note that not all issues ended up being registered. However, it is assumed that those issues would have followed a similar trend, these could be mainly grouped into five categories being: "Couldn't contact the client", "Late delivery by supplier", "Forgotten order", "Manpower shortage", "Mistakes in information".

Each category description and impact can be seen in the issue register below.

Name	Description	Impact	Number of occurances
Couldn't contact client	Either the administrative assistant or technician tried to contact the client multiple times without a response	Delay of the process	25
Late delivery by supplier	Materials were necessary to perform the service, however the supplier was late in their delivery	Reduced trust in the suppliers	9
Forgotten order	A order was put on hold, and not picked up by a technician as soon as possible	Disrupted schedules and loss of customer trust	7
Manpower shortage	There were no available technicians to attend the order	Overworked employees and high waiting times	13
Mistakes in information	Information about the service requirements, and customer details was either ommited or wrong	Influence on productivity and time needed for rework	21

Table 12 – SISDIAS's Issue register
Source – Made by the author

With the outputs of the issue register, it was then possible to create a Pareto chart, to analyze and identify the significant aspects of the overall problem.

The Pareto chart was created by assigning the frequency of the categories identified and their respective percentage. Each category was then laid out in the graph from most to least occurrences. Finally, a line was created with the summative percentages of each category. When analyzing the Pareto chart, it is possible to see then that the vital few were mainly the issues of contacting the clients and the mistakes in information by participants, with some presence of the manpower shortage, concluding that these issues needed special attention over the others, with this it was necessary to come up with a solution that could combat and reduce the occurrence of these issues.

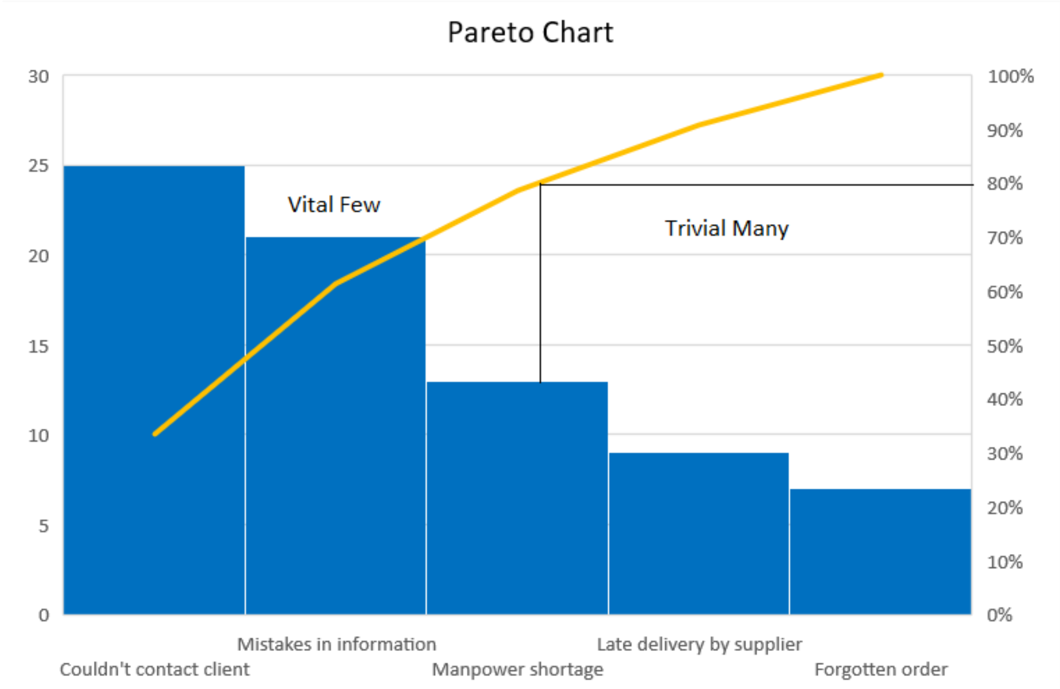


Figure 17 – Pareto chart
Source – Made by the author

4.4.6. Flow Analysis

To have a better understanding of the process's processing time and overall cycle time efficiency a flow analysis was conducted. This analysis consisted of having each identified activity be assigned a processing time, then adding each step following a set of rules. The values used were gathered through direct interviews with the process participants by asking the average time it would take them in order to complete each activity. This was later validated by direct observation of several process instances. In the cases where an exclusive gateway was found, it was necessary to assign a probability check for each path, adding the time value accordingly. When parallel gateways were found, it was necessary to calculate each separate path processing time and only add to the total the highest value. And finally, in the cases where a rework needed to be done, it was necessary to assign a rework probability adding to the total the rework processing time multiplied by its rework probability. These calculations were made by stages, where the first stage was calculated up until the activity of contacting the client, and are as follow:

$$5+\left(0.25*\frac{(3+2+\ 7+15+8)}{1-0.25}\right)$$
$$=\ 5+(0.25*46.66)=16.67$$

Each different value, as mentioned previously, represents either the processing time of separate activity or multiplication by an exclusive gateway probability. After the calculations, it was concluded that the average processing time up until the contact activity would be 51.47 minutes, which is around 16 minutes and 40 seconds.

The second stage aimed to calculate the processing time between the client's contact up until before the activity of performing the agreed-upon service.

$$1 + 3 + 2 + 10 + 5 + (0.2 * 15) + (0.3 * (10 + 8 + (0.8 * (4 + (0.7 * 20) \\ + \left(0.3 * \left(0.1 * (10 + 6) + \left(0.9 * (6 + 20)\right)\right)\right)$$

$$= 21 + 3 + 15 + 0.3 * \left(18 + \left(0.8 * \left(18 + \left(0.3 * (1.6 + 15.6)\right)\right)\right)\right)$$

$$= 39 + \left(0.3 * (18 + 0.8 * 25.3)\right)$$

$$= 39 + 11.47 = 51.47$$

This stage of the process was calculated to take on average 51 minutes and 28 seconds.

The third stage of the calculations was aimed at the activity of performing the service itself, taking into consideration the possibility of service errors and the necessity of rework to be done in said service.

$$30 + 8 + (0.25 * 3 + 10 + (15 + 11.47)$$

$$= 38 + 0.25 * 39.47$$

$$= 38 + 9.87 = 47.87$$

This stage of the process was calculated to take on average 47 minutes and 52 seconds.

Finally, the last stage of the calculation aimed to identify the processing time between the filling of the service report by the technician up until the end of the process.

$$2 + 5 + 3 + 2 + (0.75 * (4 + 6) + (0.25 * (4 + 3)$$

$$= 12 + 7.5 + 1.75 = 21.25$$

This final stage would take on average 21 minutes and 15 seconds.

The sum of the different stages of the calculations are as follows:

$$16.67 + 51.47 + 47.87 + 21.25 = 137.23$$

The overall process has a calculated 137 minutes and 14 seconds of processing time. However, the average cycle time isHowever, the average cycle time is around two workdays, which translates into 16 work hours, which is 960 minutes. In order to calculate the cycle time efficiency of the process, it was necessary then to divide the total processing time over the cycle time.

$$16 * 60 = 960'$$

$$\frac{137.23}{960} = 0.143 * 100 = 14.3\%$$

It can be concluded then that the process's cycle time efficiency is 14.3% which means that there are several waiting times throughout the process and much room for improvement.

4.4.7. Simulation

Simulation of business processes consists of experimenting and analyzing the produced business process models in a computer-generated environment. This technique provides business analysts with insights on possible bottlenecks and multiple different issues arising from either the as-is model and allows for the creation of what-if scenarios that enable the analysis of said scenarios without the risk and needed investment of experimenting with them physically.

For this case, a high-level model was created. This decision was made to have an easier understanding of the simulation results since simulating in the overall model could confuse and possibly unrealistic results. Activities that would be sequential were agglomerated into one, also maintaining important points of decision.

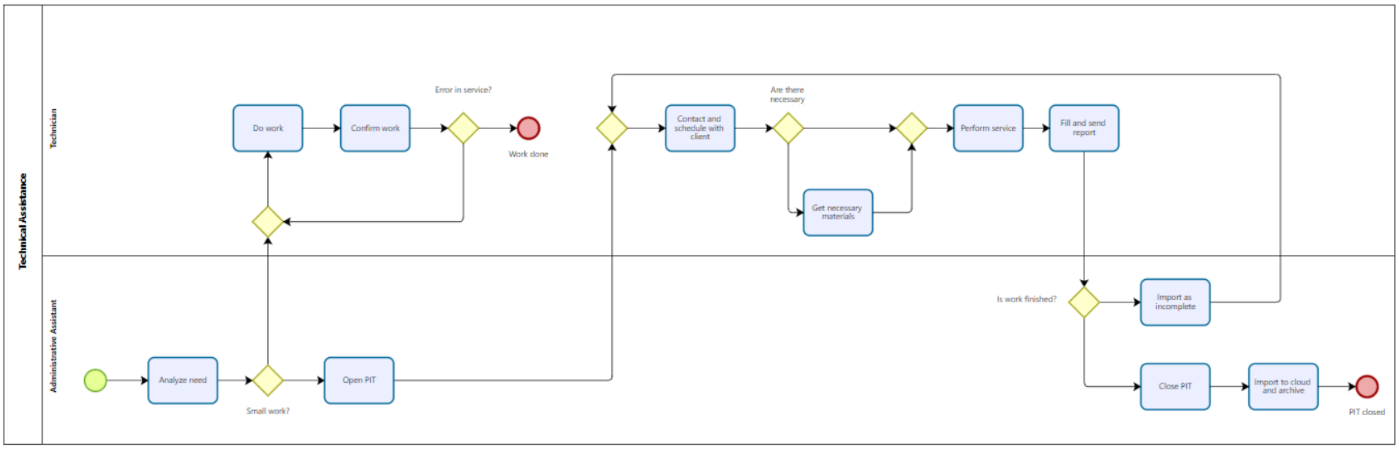


Figure 18 – Technical Assistance High-level Model
Source – Made by the author

The simulation consisted of four steps. The first step was the validation process. At this step the maximum number of created instances was established, for this simulation that number was 100, also each exclusive gateway was given a path probability. These probabilities took into consideration the values used for the flow analysis. The probability of it being categorized as a small work was 25%, 10% of there being an error on the small work, 30% of the normal service needing materials, this value can be considered low. However, this happens due to most provided services being of an accounting nature. Finally, the last exclusive gateway of the work being finished upon reaching the administrative assistant was of 75%.

The second step of the simulation was to provide each activity with a processing time. This processing time was, for almost all activities, defined as a truncated normal distribution, where a minimum value of 0 was attributed to avoid negative values not to jeopardize the simulation. Nonetheless, one of the activities, "Contact and schedule with client," was defined as having a uniform distribution due to its dependence on external entities, therefore avoiding result's contamination. The processing time values were also based on those used for the flow analysis. When agglomerations of activities were made, the resulting processing time was a sum of each activity of the original model combined. At this step, the start event also had to receive the input of the inter-arrival time. For this simulation, it was defined as one arrival every 25 minutes.

The third step was to define and assign the available resources to each activity that needed them. The resources for this process consist of two administrative assistants and six technicians, where no activity needed more than one of them at a time, i.e., activities in the administrative assistant lane took one administrative assistant as a resource. Activities in the technician lane took one technician as a resource.

Finally, the last step of the simulation was to define the calendars used in the company. The company's working schedule lasts from 9:00 AM to 01:00 PM as the morning shifts and from 02:00 PM to 06:00 PM as the afternoon shifts.

A first simulation was run only taking into consideration the time analysis, this simulation disregards the assignment of resources and therefore does not present any waiting times. The results of this simulation were very similar to the results calculated in the flow analysis above due to the flow analysis also not considering any waiting times. Where the calculations of the flow analysis were of a total processing time of around 2 hours and 17 minutes, the results of the simulation gave a processing time of around 2 hours and 11 minutes, these results demonstrated consistency between the original model and the translated high-level model.

When simulation the model with the assigned resources, it was observed that the resource utilization was of much greater scale for the technicians (≈90%) than for the administrative assistants (≈50%)

since during the process cycle there is much more processing time in the hands of the technicians than that in the hands of the administrative assistants. This is in pair with what was predicted, due to the technician's jobs being primarily the technical assistance of the clients, and the administrative assistant needing to participate in a larger number of processes. The average process time increases to 2 hours and 43 minutes.

When applying the calendar analysis, it can be noticed that the total processing time of the 100 instances increases substantially, from 8 days to 15 workdays. This can be seen as correlating to the fact that each workday is constituted of 8 work hours. On the simulation without this option the software considers that the workday is 24 hours. Therefore it is pretty natural to have an increase in total time. The average process time also increases substantially to 3 hours and 40 minutes, one hour more than the simulation without calendars and one and a half hours more than the simulation without resources.

After performing a what-if analysis where one more technician was available at full time, it was noted that the average process time would massively drop from 3 hours and 40 minutes to 2 hours and 27 minutes.

This drop-in cycle time resulted in a decrease in the total time to complete 100 instances by over five workdays. The table below presents some of the activities' times from the current scenario in the company and the results of the what-if scenario, which adds a new technician to the resources.

Activity	**Current scenario**	**What-if scenario**
Do work	57.5 minutes	34 minutes
Confirm work	33.5 minutes	12.3 minutes
Contact client	56 minutes	38 minutes
Get materials	1 hour and 19 minutes	49 minutes
Perform service	1 hour and 40 minutes	1 hour and 4 minutes
Fill report	1 hour and 20 minutes	44 minutes

Table 13 – Simulation results
Source – Made by the author

Several activities performed by the administrative assistants were taking a slight increased average time to be completed, this can be traced to the fact then when the technicians are completing work faster, this work is traveling to the administrative assistants at a higher rate, increases the waiting time on the activities performed by them.

The highest waiting times were still by the technicians, however, these dropped by around 75 to 80% of the original scenario, e.g., 22 minutes to 5 minutes of average waiting time for the activity of getting materials, and 21 minutes to 4 minutes for the activity of performing the service itself.

A possible conclusion for this scenario is that acquiring an additional competent technician could provide the company with better technical assistance cycle times.

Another what-if scenario ran consisted of assuming the reduction of the processing times for activities that are currently non-digital, by implementing a possible digitization solution and reducing its completion time by an assumed 50%.

The results of this scenario were as follows:

1. The average processing time was reduced from 3 hours and 40 minutes to 2 hours and 50 minutes.
2. The total waiting time for resources dropped by half from 6 days and 6 hours to 3 days and 22 hours.
3. Since the activities affected by this change were of the responsibility of the administrative assistant, its resource utilization was reduced further than the resource utilization of the technicians, 50% to 32% and 89% to 88%, respectively.

A scenario with the combination of the two past changes would both reduce the incoming work to the technicians and administrative assistant, due to relieving some waiting times for the availability of technicians, allowing for a smoother process flow, and by avoiding time wastes by needing to fill the forms manually.

4.5. Process Redesign

The redesign stage for the creation of a To-Be model of the process of Technical Assistance took into consideration both several redesign heuristics as well as the previously conducted analysis.

Most redesign actions were performed in the administrative assistant pool.

An implementation of an information system was proposed. This system would eliminate multiple unnecessary tasks, such as “Open PIT” by the administrative assistant, as well as tasks that consisted of forwarding and receiving the necessary information to perform the process. Since this system would bring a centralized repository of information, it would no longer be necessary to create physical documentation as well as no longer being necessary to keep forwarding the information via e-mail, maintaining every open task on the same platform. This information system can also provide a decrease of defects due to reducing the human work and consequentially the number of human errors.

A ticket system was also proposed to alleviate the inputs by the administrative assistants, enabling automatic management of tasks and prioritization of work.

The initial exclusive gateway of checking if the identified need was a “Small work”, was removed entirely. This gateway was made in order to check if it was necessary to open a PIT manually, and since the implementation of a system would remove the need to create manual documents these activities could be eliminated.

It was necessary to create an exclusive gateway for the cases where there was not enough information provided by the client upon filling a ticket. If this were the case, the administrative assistant would contact the client directly from the system, receiving a notification upon a response from the client.

When the administrative assistant deems having all necessary information it would then check the availability of each technician and assign that ticket to the most appropriate. The technician would then receive a notification where he could access the system and review the service requirements.

A triage heuristic was applied generalizing the activities that referred to previously identified services as minor works, treating each service the same independently of the considered amount of work to be done.

Resequencing of steps was also proposed in having any possible materials analyzed remotely instead of presential with the client after the first contact. This change could reduce the unnecessary steps of having the technician move to the location in cases where the client wouldn’t accept the presented budget or the materials were not available. A parallelism enhancement was also added where the technician would both contact the client and schedule the service simultaneously.

During the material analysis and service performance, any information registration would be inserted directly in the system with each automatic timestamp, this allows for a quicker registration, providing both the administrative assistant and senior management with a better understanding of the flow of each service. The step of calculating the total cost of the necessary materials would also be automated, reducing both the cycle time, defect rate, and workload of the technicians.

Another change made to the model was that of the cases where the client does not approve the presented budget, neither does he provide the necessary materials, wherein the “as-is” model this would result in the creation of a service report and need for archive, in this “to-be” model it is handled by the system, only requiring the technician to register the specific reasons for the closing of the ticket.

When encountering service errors upon testing, the technicians register all the required information in the system, where in the future he can return to the ticket, analyze all the previously gathered information, and initiate the rework.

The final segment of the process model represents the activities taken to close the ticket. The main differences between the “to-be” and “as-is” models are the removal of the digitization and physical archive of documents, as well as the creation of a new end event representing the suspension of the ticket. This suspension end event represents that the ticket was not fully completed and needs to be re-opened as soon as possible, returning to the beginning of the process, to be treated as a completely new ticket that has the difference of having all the registrations of information associated with it.

It can be noted that with these applied changes, multiple wastes identified in the different analysis is minimized and some eliminated, e.g., regarding waste analysis transportation wastes such as the physical movement to the archives and printer were eliminated, as well as a reduction in the transportation of materials when the client does not agree to the budget, defect wastes can be reduced with the automation of certain activities, e.g., mistakes in service requirement inputs, removal of duplicate data entries due to centralized information in the form of every registration being made in the same place, consequentially, when fewer mistakes are made in the handling of the ticket, the amount of overall rework is indirectly reduced.

The proposed solution could also reduce the number of issues identified through the issue register and Pareto analysis, mainly the wrong data entries and workforce shortage, due to having a better understanding of each technician work, enabling for better management of workload distribution, as well as the automation in ticket creation and removal of necessary duplicate data entries. Regarding the issues where the client could not be contacted, since they reside outside the organization itself, it poses different ways of reducing them. This could be solved through training the employees on customer handling, having scheduled follow-up meetings, or having automated e-mails be sent out a specific time before each previously scheduled meeting

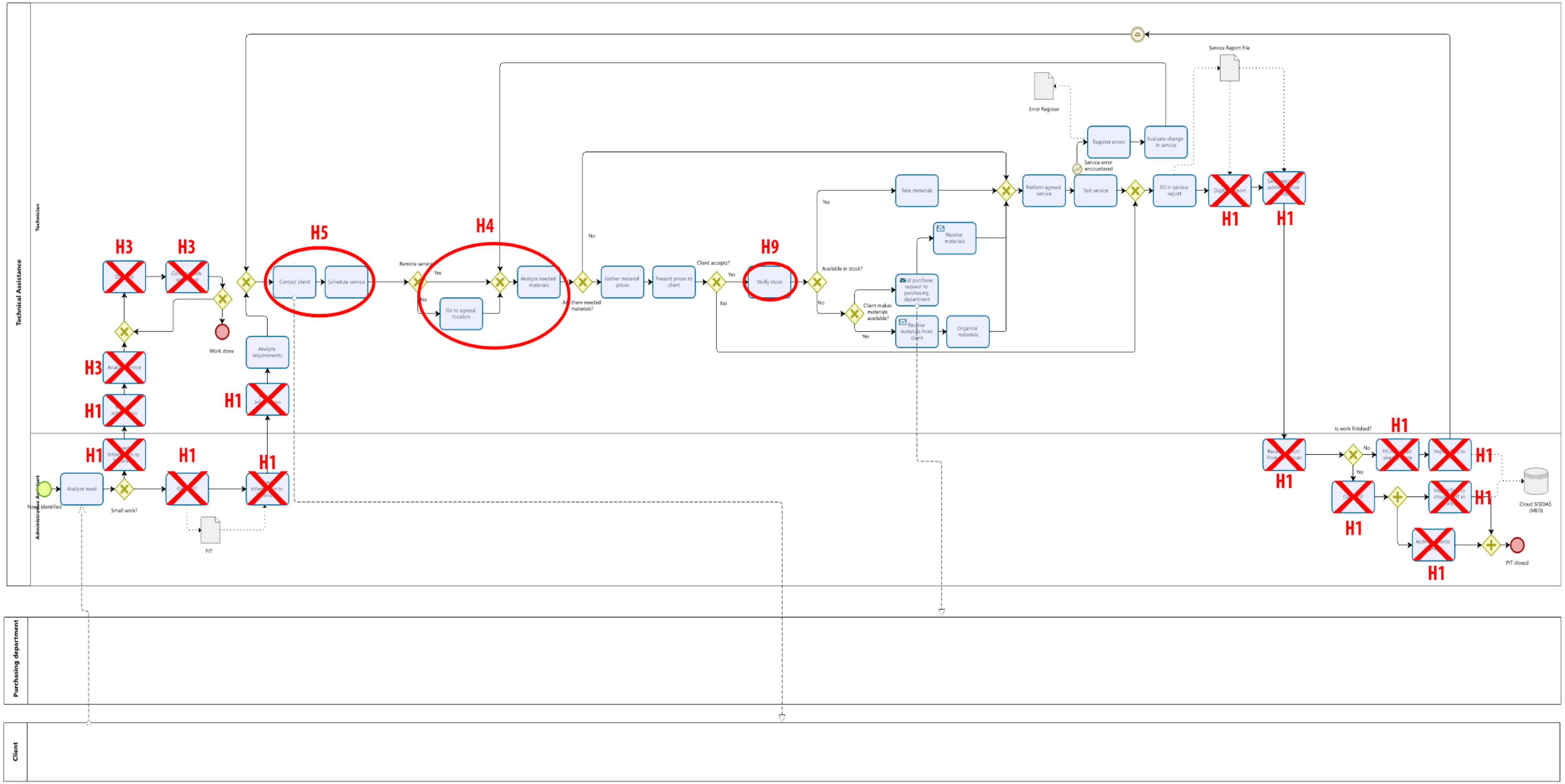


Figure 19 – Applied heuristics to the as-is process model
Source - Made by the author

Heuristic	Heuristic name	Heuristic description
H1	Task elimination	Elimination of non-value adding steps
H3	Triage – Generalization	Integration of tasks into a general task
H4	Re-sequencing	Re-ordering of tasks to avoid over-processing
H5	Parallelism enhancement	Parallelization of tasks to reduce cycle time
H9	Automation	Utilization of data sharing and network technology to improve information availability and flow

Table 14 – Heuristic Labels
Source: Made by the author

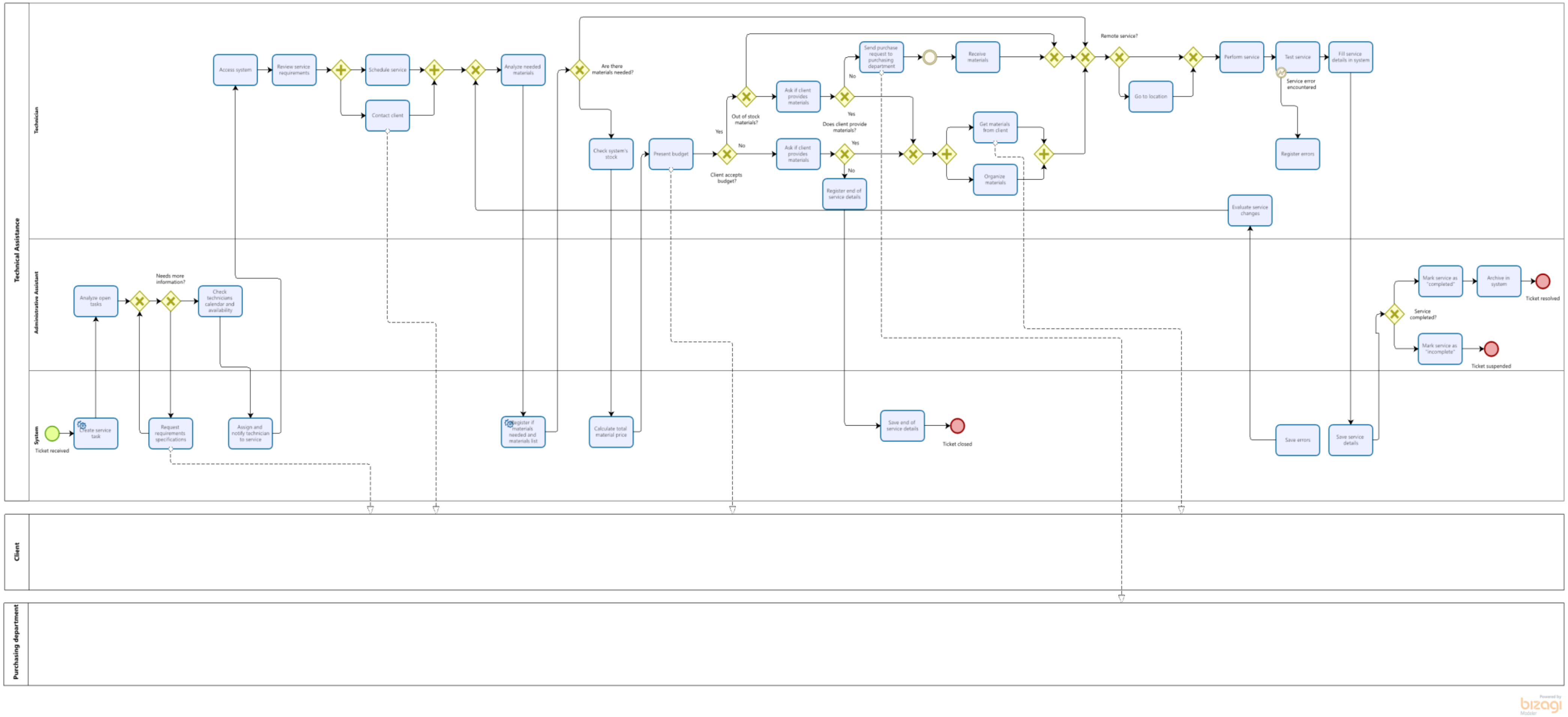


Figure 20 – Issue-to-resolution To-Be process model
Source – Made by the author

4.6. Software Implementation

In this section, there is going to be an overview of the steps carried out in order to implement the proposed changes for the Technical Assistance process. These changes consisted of an implementation of a modular ERP in the company. This ERP would take the role of the information system that would handle the different activities, automating them, and therefore reducing the workload of the employees, the process average cycle time, and the number of defects.

Several possible systems were analyzed in which the main feature searched for was to have the capability of easy software customization to obtain more in-depth adaptability of the organization's process to the system itself. The organization wasn't able to change every internal process simultaneously. Therefore the system would have to be of a modular nature to allow for a simple, iterative, and effective adoption.

Upon multiple meetings with the senior management and several process participants, the chosen system to be implemented in the company was the ODOO ERP. This system offers the needed solutions where it works by modules. These modules, denominated "apps" in the system, ranging from a CRM system to invoicing systems, marketing automation, etc.

For this first phase of implementation, the modules of Helpdesk, Field Service, and Studio were proposed. The Helpdesk module consists of a ticket system. Tickets can be opened in various ways, depending on certain circumstances, the module offers the creation of tickets by email, assigning to each team depending on the email aliases, tickets can also be created from website forms, from leads, or manually if necessary. This module also provides the creation of SLA rules for each type of ticket, customer rating, for tracking quality metrics, and a helpdesk dashboard to provide the employees and managers with an overview of opened, closed, suspended, and archived tickets. This module can work directly with the Field Service module. The Field Service module aims to aid the employees when the technical assistance requests are on the site, allowing for easier scheduling of activities, plan of routes, track of time spent, assignment of tasks to employees (similarly to the help desk module), and even sell products during the service itself. Both the Helpdesk and Field Service modules offer a Kanban view in order to help participants to stay organized by giving a simple overview of tasks. Finally, the last module to be proposed was the Studio module, this module allows for total customization of other apps in a code-less way, if desired, also offering developer tools for more advanced technical details if needed, since the software is Open-Source. These features range from customizing the necessary inputs when opening a ticket, creating adaptable and specific documents and forms, changing the views of the tasks, amongst others.

For the implementation of this system, it was necessary to undergo several training sessions where the users would test with the system offering feedback as they go. These training sessions were carried out online in a roled-based training approach, i.e., the provided training was, at a certain level, customized to each specific role with task-based training and collaboration.

A team inside the company was gathered to develop the necessary changes so that the system would be aligned, to some extent, with the company's goals and methods of work. Customization of required inputs of data, automated documents, and creation of reports for future analysis was worked upon by participants of several departments of the company. This work included the senior management, who overviewed the entirety of the project.

The implementation of the system followed a pilot test of two weeks, where data was not migrated from the previous software, but some new entries were made using Odoo, the reason for this decision was mainly to identify and understand possible current issues without compromising and disrupting the ongoing work, and overcommitting to a flawed setup. During this pilot, multiple concerns were presented by the users. These include non-optimal input boxes placement and missing required information. Upon gathering feedback from the user's multiple changes were proposed, considering those statements.

The internship period finished after the completion of the pilot test, where, at that time, the software was not yet fully operational and optimal.

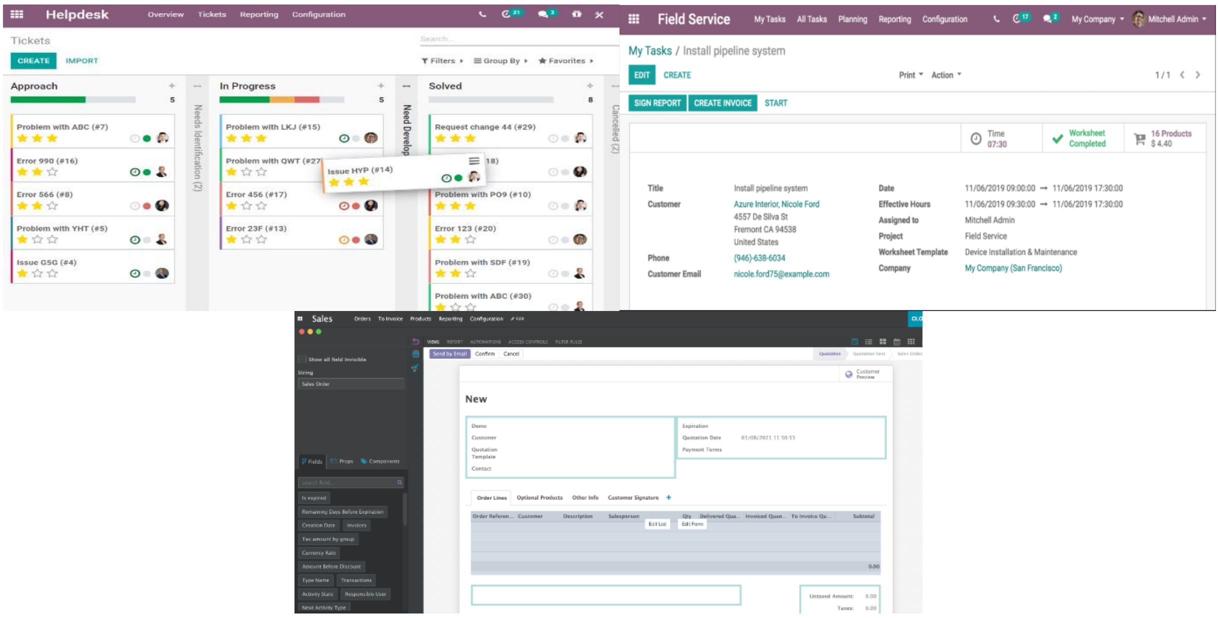


Figure 21 – Odoo module's point of view
Source – (Odoo, 2021)

5. CONCLUSIONS

In this chapter, it is presented an overall summary of the actions taken during the internship period, as well as some faced limitations and recommendations for future work inside the organization.

5.1. Overall summary of the internship

The main goal of the proposed project was to apply the acquired knowledge about the methodology of BPM in a professional setting. This experience allowed for a better grasp of the overall professional environment that revolves around organizations in an era that has increasingly become digitized and technology-oriented. Even though SISDIAS is a small company, it is well-established in the Azorean archipelago, working within multiple islands. These characteristics created a glimpse of what working in a larger and more developed organization could be. Even though the project required working with everyone inside the organization, most of the work was performed in a smaller team, primarily consisting of the intern, the executive director, one administrative assistant, and one technician. The intern also had the opportunity to enhance his academic knowledge regarding using different tools such as the Bizagi modeler tool and the Odoo ERP different modules. Soft skills such as communication, teamwork, time-management, problem-solving were also further developed throughout the internship.

Firstly, a literature review was developed with the aim of understanding the current state of the art regarding both the BPM methodology and EPM concepts. An assessment of SISDIAS's BPM maturity was made, identifying that the organization is still at a relatively low level of maturity. An identification of the processes of the organization was made, applying prioritization rules to choose which process should receive the BPM approach. Upon identifying the Technical Assistance process as the adequate one, it was necessary to model the current As-Is process. To accomplish this goal, multiple techniques of information gathering were applied. Several analyses were conducted to understand where the process could be improved, qualitative analysis such as value-added analysis and waste analysis allowed for the identification of unnecessary activities, quantitative analysis such as flow analysis and simulation had the goal of understanding how the current process was handled and how could changes be made. Upon completion of this analysis, a To-Be process model was created, considering both the redesign heuristics and the results of the previous analysis. Finally, the implementation of the changes in the process is presented.

5.2. Limitations and recommendations for future works

Any project, research, or internship comes with some limitations and issues. At the start of the internship, there was an immediate necessity to work remotely due to both the COVID-19 pandemic and ongoing constructions on the organization’s facilities, this problem brought delays to the project. Due to its presence in multiple islands, there was a need for transportation between them, raising challenges for time and cost management. As mentioned previously, the internship period ceased two weeks into the conduction of the pilot, which was not ideal due to the inability to complete the intended project. Since the organization is not extensively experienced in projects of this nature, several misjudgments of time-frames and unfeasible results were expected. This experience provided both the senior management and the company with a better understanding of process improvement initiatives adoption, allowing for future projects to be implemented without many delays. A larger team dedicated to the project would be necessary given the case of success after the overall implementation; this success would be dependent on the willingness of both senior management and process participants to adopt several initiatives for process improvement, as well as good and present management of said projects. As for future work, this team would be monitoring the performance of the system on a larger time scale and, if feasible, apply the methodology to further processes, bringing an overall improvement in cycle times, process quality, and customer satisfaction.

6. BIBLIOGRAPHY

Aagesen, G., & Krogstie, J. (2014). BPMN 2.0 for Modeling Business Processes. *Handbook On Business Process Management 1*, 219-250. doi: 10.1007/978-3-642-45100-3_10

Abu Al-Rub, F., Shibhab, P., & Abu Al-Rub, S. (2020). *Quality Management Systems (ISO 9001:2015)* [Ebook]. Lisle, Illinois, USA: GAVIN eBooks.

Ahmed, M., & Ahmad, N. (2011). An Application of Pareto Analysis and Cause-and-Effect Diagram (CED) Minimizing for Rejection of Raw Materials in Lamp Production Process. *Management Of Science And Engineering*, *5*(3), 87-95. doi: 10.3968/j.mse.1913035X20110503.320

Al Barrak, F., Al Meriouh, Y., & Zniber El Mouhabbis, M. (2017). Work In Process stock integrity in the automotive industry. *Production & Manufacturing Research*, *5*(1), 2-14. doi: 10.1080/21693277.2017.1322543

Art of Lean. (2000). *Toyota Production System: Basic Handbook*

Association of Business Process Management Professionals. (2013). *Guide to the business process management common body of knowledge: ABPMP BPM CBOK®*. Chicago, Ill: Association of Business Process Management Professionals

Ayad, A. (2010). Critical thinking and business process improvement. *Journal Of Management Development*, *29*(6), 556-564. doi: 10.1108/02621711011046521

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing Maturity Models for IT Management. *Business & Information Systems Engineering*, *1*(3), 213-222. doi: 10.1007/s12599-009-0044-5

Bezerra, M., Tavares, M., & Silva, R. (2018). Gerenciamento dos processos de negócio: uma análise dos modelos de ciclo de vida BPM. *Revista Produção Online, 18*(3), 796-825. doi: 10.14488/1676-1901.v18i3.2905

Bizagi. (2021). Bizagi Modeler User Guide - A Business Process Modeling Tool. Retrieved 15 April 2021, from https://help.bizagi.com/process-modeler/

BonitaSoft. (2021). Retrieved 15 April 2021, from https://documentation.bonitasoft.com/bonita/2021.1/

Brook, O., Kruskal, J., Eisenberg, R., & Larson, D. (2015). Root Cause Analysis: Learning from Adverse Safety Events. *Radiographics*, *35*(6), 1655-1667. doi: 10.1148/rg.2015150067

Bruin, T. & Rosemann, M. (2005). Towards a Business Process Management Maturity Model. *Proceedings of the 13th European Conference on Information Systems,* 521–532.

Bruin, T.D., Rosemann, M. (2007). Using the Delphi technique to identify BPM capability areas. *ACIS Proceedings*, 642–653.

Bruin, T.D. (2009). Business process management: theory on progression and maturity.

Business Process Management Enables Digital Transformation in 2020. (2020). Retrieved 25 January 2021, from https://kissflow.com/bpm/how-bpm-is-taking-a-central-role-in-digital-transformation/

Butzer, S., Schötz, S., & Steinhilper, R. (2017). Remanufacturing Process Capability Maturity Model. *Procedia Manufacturing*, *8*, 715-722. doi: 10.1016/j.promfg.2017.02.092

Cho, C., & Lee, S. (2011). A study on process evaluation and selection model for business process management. *Expert Systems With Applications, 38*(5), 6339-6350. doi: 10.1016/j.eswa.2010.11.105

Chrissis, M., Konrad, M., & Shrum, S. (2011). *CMMI for development* (3rd ed.). Upper Saddle River, NJ: Addison-Wesley.

Coccia, M. (2018). The Fishbone diagram to identify, systematize and analyze the sources of general purpose Technologies. *Journal of Social and Administrative Sciences*, *4*(4), 291-303.

Conger, S. (2010). Six Sigma and Business Process Management. *Handbook On Business Process Management 1*, 127-148. doi: 10.1007/978-3-642-00416-2_6

Davenport, T. (1992). Process Innovation: Reengineering Work through Information Technology.

Dijkman, R., Dumas, M., & Ouyang, C. (2008). Semantics and analysis of business process models in BPMN. *Information And Software Technology*, *50*(12), 1281-1294. doi: 10.1016/j.infsof.2008.02.006

Dumas, M., Rosa, M. L., Mendling, J., & Reijers, H. A. (2018). *Fundamentals of Business Process Management*. Springer Berlin Heidelberg.

Fellmann, M., Bittmann, S., Karhof, A., Stolze, C., & Thomas, O. (2013). Do we need a standard for EPC modelling? The state of syntactic, semantic and pragmatic quality. *Enterprise modelling and information systems architectures (EMISA 2013)*.

Furterer, S. (2009). *Lean Six Sigma in service: Applications and case studies*. Boca Raton: CRC Press.

Gošnik, D. (2019). Core Business Process Management and Company Performance. *Management, 14*(1), 59-86. doi: 10.26493/1854-4231.14.59-86

Jeston, J., & Nelis, J. (2013). *Business process management: Practical Guidelines for Successful implementations* (3rd ed., pp. 40-44). Oxford, UK: Butterworth-Heinemann.

Ko, R., Lee, S., & Wah Lee, E. (2009). Business process management (BPM) standards: a survey. *Business Process Management Journal, 15*(5), 744-791. doi: 10.1108/14637150910987937

Laguna, M., & Marklund, J. (2019). *Business process modeling, simulation and design* (3rd ed.). Boca Raton, FL: CRC Press.

Lehmann, C., & Kutnick, D. (2012). *Strategy and business process management*. Boca Raton: Taylor & Francis.

Lemańska-Majdzik, A., & Okręglicka, M. (2015). Identification of Business Processes in an Enterprise Management. *Procedia Economics And Finance, 27*, 394-403. doi: 10.1016/s2212-5671(15)01011-4

Leopold, H., Mendling, J., & Polyvyanyy, A. (2012). Generating Natural Language Texts from Business Process Models. *Notes On Numerical Fluid Mechanics And Multidisciplinary Design*, 64-79. doi: 10.1007/978-3-642-31095-9_5

Liu, C., Li, Q., & Zhao, X. (2009). Challenges and opportunities in collaborative business process management: Overview of recent advances and introduction to the special issue*. Information Systems Frontiers, 11*(3), 201-209. doi: 10.1007/s10796-008-9089-0

Matei, G. (2011). SOA and BPM, a Partnership for Successful Organizations. *Informatica Economica*, *15*(4).

Murugaiah, U., Jebaraj Benjamin, S., Srikamaladevi Marathamuthu, M., & Muthaiyah, S. (2010). Scrap loss reduction using the 5-whys analysis. *International Journal Of Quality & Reliability Management*, *27*(5), 527-540. doi: 10.1108/02656711011043517

Open Source ERP and CRM | Odoo. (2021). Retrieved from https://www.odoo.com/

OMG. (2013). *Business Process Model and Notation (BPMN)*. Retrieved 15 April 2021, from https://www.omg.org/spec/BPMN

Oracle. (2021). Fusion Middleware Modeling and Implementation Guide for Oracle Business Process Management. Retrieved 13 April 2021, from https://docs.oracle.com/cd/E23943_01/doc.1111/e15176/toc.htm

Owen, M., & Raj, J. (2003). BPMN and business process management. *Introduction to the new business process modeling standard*.

Paul, J. & Criado, A., (2020). The art of writing literature review: What do we know and what do we need to know?. *International Business Review, 29*(4)

Pereira, J., & Freitas, A. (2019). TOWARDS A CHARACTERIZATION OF BPM TOOLS' SIMULATION SUPPORT: THE CASE OF BPMN PROCESS MODELS. *International Journal For Quality Research, 13*(4), 783-796. doi: 10.24874/ijqr13.04-02

Prajogo, D., & Sohal, A. (2006). The integration of TQM and technology/R&D management in determining quality and innovation performance. *Omega*, *34*(3), 296-312. doi: 10.1016/j.omega.2004.11.004

Process. (2021). Oxford Advanced Learners Dictionary. Retrieved from https://www.oxfordlearnersdictionaries.com/definition/english/process1_1

Proença, D., & Borbinha, J. (2016). Maturity Models for Information Systems - A State of the Art. *Procedia Computer Science*, *100*, 1042-1049. doi: 10.1016/j.procs.2016.09.279

Pyon, C., Woo, J., & Park, S. (2011). Service improvement by business process management using customer complaints in financial service industry*. Expert Systems With Applications, 38*(4), 3267-3279. doi: 10.1016/j.eswa.2010.08.112

Reijers, H., & Mansar, S. (2005). Best practices in business process redesign: an overview and qualitative evaluation of successful redesign heuristics. *Omega*, *33*(4), 283-306. doi: 10.1016/j.omega.2004.04.012

Rosemann, M. & de Bruin, T. (2004). Application of a Holistic Model for Determining BPM Maturity. *Proceedings of the AIM Pre-ICIS Workshop on Process Management and Information Systems (Actes du 3e colloque Pre-ICIS de l'AIM)*. Eds. J. Akoka, I. Comyn-Wattiau, M. Favier. Washington, D.C., 12 December 2004, (pp. 46-60).

Rosenkranz, C., Seidel, S., Mendling, J., Schaefermeyer, M., & Recker, J. (2010). Towards a Framework for Business Process Standardization. *Business Process Management Workshops*, 53-63. doi: 10.1007/978-3-642-12186-9_6

Rudden, J. (2007). Making the Case for BPM : A Benefits Checklist.

Sarkar, D. (2009). 8 Wastes of Lean Manufacturing in a Services Context. Retrieved 12 April 2021, from https://www.processexcellencenetwork.com/lean-six-sigma-business-performance/columns/8-wastes-of-lean-manufacturing-in-a-services-conte

Schmidt, W., & Fleischmann, A. (2013). Business Process Monitoring with S-BPM. *Communications In Computer And Information Science*, 274-291. doi: 10.1007/978-3-642-36754-0_18

Schwegmann, A., & Laske, M. (2010). As-Is Modeling and Process Analysis. In Becker, J., Kugeler, M., Rosemann, M., (Eds.), *Process Management*, (pp. 133-156). Berlin: Springer.

Shou, W., Wang, J., Wu, P., & Wang, X. (2019). Value adding and non-value adding activities in turnaround maintenance process: classification, validation, and benefits. *Production Planning & Control*, *31*(1), 60-77. doi: 10.1080/09537287.2019.1629038

Skhmot, N. (2017). The 8 Wastes of Lean. Retrieved 12 April 2021, from https://theleanway.net/The-8-Wastes-of-Lean

Spanyi, A. BPM Governance | BPMInstitute.org. Retrieved 16 April 2021, from https://www.bpminstitute.org/resources/articles/bpm-governance

Soliman, M., (2017). A COMPREHENSIVE REVIEW OF MANUFACTURING WASTES: TOYOTA PRODUCTION SYSTEM LEAN PRINCIPLES. 22. 1-10. 10.6084/M9.FIGSHARE.9121283.

Stirna, J., Persson, A., & Sandkuhl, K. (2007). Participative Enterprise Modeling: Experiences and Recommendations. *Notes On Numerical Fluid Mechanics And Multidisciplinary Design*, 546-560. doi: 10.1007/978-3-540-72988-4_38

Stravinskiene, I., & Serafinas, D. (2020). The Link between Business Process Management and Quality Management. *Journal Of Risk And Financial Management, 13*(10), 225. doi: 10.3390/jrfm13100225

Taymouri, F., Rosa, M., Dumas, M., & Maggi, F. (2021). Business process variant analysis: Survey and classification. *Knowledge-Based Systems*, *211*, 106557. doi: 10.1016/j.knosys.2020.106557

Van der Aalst, W. (2011). *Process Mining: Discovery, Conformance and Enhancement of Business Processes* (1st ed.). Berlin: Springer-Verlag Berlin Heidelberg.

Van Looy, A., & Rotthier, S. (2018). Kiss the Documents! How the City of Ghent Digitizes Its Service Processes. In: vom Brocke, J., Mendling, J. (eds) *Business Process Management Cases. Management for Professionals*, (pp. 187-204). Springer, Cham. https://doi.org/10.1007/978-3-319-58307-5_11 vom Brocke, J., Mathiassen, L., & Rosemann, M. (2014). Business Process Management. *Business & Information Systems Engineering, 6*(4), 189. doi: 10.1007/s12599-014-0330-8

vom Brocke, J., & Rosemann, M. (2015). *Handbook on Business Process Management 1: Introduction, Methods, and Information Systems* (2nd ed.). Springer.

vom Brocke, J., Zelt, S., & Schmiedel, T. (2015). Considering Context in Business Process Management: The BPM Context Framework.

vom Brocke, J., & Mendling, J. (2018). Frameworks for Business Process Management: A Taxonomy for Business Process Management Cases. *Business Process Management Cases*, 1-17. doi: 10.1007/978-3-319-58307-5_1

Wahab, A., Mukhtar, M., & Sulaiman, R. (2013). A Conceptual Model of Lean Manufacturing Dimensions. *Procedia Technology*, *11*, 1292-1298. doi: 10.1016/j.protcy.2013.12.327

Weber, C., Curtis, B., & Gardiner, T. (2008). *Business Process Maturity Model (BPMM) Version 1.0.*

Zelt, S., Recker, J., Schmiedel, T., & vom Brocke, J. (2018). A theory of contingent business process management. *Business Process Management Journal*, *25*(6), 1291-1316. doi: 10.1108/bpmj-05-2018-0129