

Development of RPA for Administrative Processes in a Cork Industry

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Abstract

The recent implementation of SAP, System and Applications and Products in Data Processing, in the company Amorim Cork S. A. has led to an increase in employee workload, as its implementation has resulted in the creation of a much larger volume of bureaucracy that is necessary for processes to run smoothly.

On the other side, the Fourth Industrial Revolution, commonly called Industry 4.0, the moment we are currently in, is a technology revolution that seeks to integrate intelligent systems into businesses and in people's daily lives.

Intelligent systems may include artificial intelligence, to cobots (collaborative robots, robots designed for direct collaboration with humans in a shared space), and even virtual and augmented reality. This revolution aims at facilitate cooperation between physical and virtual systems.

The combination of the two aforementioned factors has created an interest in automating repetitive and routine tasks performed by humans through the use of computers.

RPA, or Robotic Process Automation, is an increasingly popular solution to this issue, as it is a relatively simple, speedier technology with a reasonable cost of deployment that is compatible with Industry 4.0. This technology provides businesses the ability to decrease expenses and boost productivity in support areas.

This thesis assesses the current state of RPA inside the company, given that it had already been implemented for approximately one year. It presents the processes that were in the company's pipeline to be implemented and studies their feasibility. Finally, it presents and compares costs, both of implementation and the current cost of an employee to carry out each process.

Resumo

A recente implementação de SAP, *System and Applications and Products in Data Processing*, na empresa Amorim Cork S. A. gerou um aumento da carga de trabalho dos colaboradores, pois a sua implementação criou um volume muito maior de burocracias cuja realização é imperativa para que os processos fluam sem constrangimentos.

Por outro lado, a Quarta Revolução Industrial, comumente designada Indústria 4.0, momento em que nos encontramos atualmente, é uma revolução tecnológica que visa a integração de sistemas inteligentes nas empresas e na vida das pessoas.

Os sistemas inteligentes podem ser desde a inteligência artificial, aos cobots (robots colaborativos, robots que se destinam à colaboração direta com um humano num espaço compartilhado), e até a realidade virtual e aumentada. Esta revolução tem como objetivo uma cooperação flexível entre sistemas físicos e virtuais.

A conjugação dos dois fatores acima mencionados despertou o interesse na automatização de tarefas repetitivas e rotineiras realizadas pelo ser humano através da utilização de computadores.

A resposta cada vez mais emergente para este problema é o RPA, *Robotic Process Automation*, que se traduz numa tecnologia relativamente fácil, mais rápida, com um custo de implementação não muito elevado e que se enquadra na Indústria 4.0. Esta solução representa uma oportunidade de redução de custos para as empresas e o aumento de produtividade nas áreas de suporte.

Esta tese avalia o estado atual do RPA na empresa, dado que o mesmo já se encontrava implementado há aproximadamente um ano. Apresenta os processos que se encontravam no pipeline da empresa para serem implementados e estuda a viabilidade dos mesmos. Por último apresenta e compara custos, tanto de implementação como o custo atual de um funcionário para a realização de cada processo.

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"The greater our knowledge increases the more our ignorance unfolds."

John F. Kennedy

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Acronyms and Symbols

ACDE	Amorim Cork Deutschland
API	Application Programming Interface
BP	Business Partner
BPM	Business Process Modeling
BPMN	Business Process Modeling Notation
BU	Business Unit
DFD	Data Flow Diagram
ERP	Enterprise Resource Planning
FTE	Full-Time Employee
MES	Manufacturing Execution System
KPI	Key Performance Indicator
OCR	Optical Character Recognition
OM	Operations Manual
RPA	Robotic Process Automation
SAP	System Applications and Products

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Chapter 1

Introduction

1.1 Context and Motivation

The steady evolution of the business environment and the exponential expansion of information and communication technology have led to alterations in how processes are seen inside an organization. Processes must be regularly monitored, measured, and modified in order to stay up with the present dynamic and constantly shifting paradigm (Dave, 2017). Improving the efficacy and performance of industrial processes requires a combination of systems and procedures to implement these organizational framework enhancements (Lamghari et al., 2018).

As the global leader in the cork industry (manufacturing and distribution of cork stoppers), Amorim Cork has both the necessity and the desire for continuous expansion. This expansion entails innovation not just in the production of cork stoppers but also in the digital realm. The adoption of an integrated management system in a business is a critical step in ensuring its future success and viability. As a result, Amorim Cork made the choice to adopt an ERP a bit too late (in 2019), after moving data to MES in 2018 as part of its digital transformation strategy. SAP was implemented primarily to improve data processing and standardize the company's information flow.

With the introduction of SAP having occurred a few years prior and the processes having had ample time to develop, it was now the right moment to investigate the viability of the RPA project and the processes for which this tool made sense.

1.2 The Company

1.2.1 Amorim Group

The Amorim Group started its activity in 1870 with the establishment, at the Gaia Pier, of a manual cork stopper production factory and has grown to become one of the largest and most dynamic multinationals of portuguese origin. The great potential of cork was perceived by the company very early on, so there was a major investment in research and development, innovation and design, enabling it to perfect a portfolio of products, objects and solutions of high added

value. In the 1960s, with the start of the company's overseas expansion, a verticalisation strategy also began, aimed at achieving world leadership in the production and export of cork products.

Nowadays the group is composed by 18 industrial plants, 10 industrial raw material plants, 12 joint ventures, 51 distribution companies and thousands of clients all over the world.

The Amorim Group's mission is "To add value to cork in a competitive, distinctive and innovative way that is in perfect harmony with nature."

On the other hand, its vision is "To be a sustainable company, providing suitable value for the capital invested while promoting social equity and environmental safeguards, with differentiating factors at product and service level"

There are 5 values that guide the group: Pride, Ambition, Initiative, Sobriety and Attitude (Amorim, 2021).

The Amorim Group is divided into five distinct business units: (Amorim, 2021)

- **Raw-materials:** This unit is represented by Amorim Florestal which main goal is to deliver cork as a raw material to Corticeira Amorim's other business units after procuring, sourcing, purchasing, stocking and preparing it.
- **Floor and wall coverings:** Amorim Cork Flooring stands as a world leader in the manufacture of versatile, high-quality cork flooring and wall decorations that are suited for any home, commercial or corporate project and have proven sustainability credentials.
- **Composite cork:** The main purpose of this unit is to reinvent the environment in a sustainable manner and assign new applications, shapes, and functionalities to cork. Amorim Cork Composites is the company that aspires to reach this objective by studying, developing, and producing high-performance cork composites.
- **Insulation Cork:** Amorim Cork Insulation is committed to producing high-tech agglomerated cork solutions that are 100% natural acoustic, thermal, and anti-vibration insulation.
- **Cork Stoppers:** Amorim Cork is the largest manufacturer, supplier and distributor of cork stoppers in the world. Advanced manufacturing technology, unmatched security in the delivery of the latest generation of products.

1.2.2 Amorim Cork

Amorim Cork, S. A. was founded in 1922, in Santa Maria de Lamas, and is the factory that gave rise to the group of companies of the Amorim Group known today. As the business has evolved, this BU currently has subsidiaries in a variety of wine-producing markets worldwide. Annually, 5.5 billion cork stoppers are manufactured in this BU. The cork stoppers produced can be used for still, sparkling and spirit wines.

1.3 Project Objectives

The project's aims are to automate a selection of repetitive, non-value added and resource-intensive jobs in the company's support areas in order to enhance productivity in these departments. It also seeks to enhance error management and the management and assessment of new automation-candidate processes. Six processes were studied and three were developed in RPA, involving the department of Logistics, Management Control and Administrative and Financial. In order to automate the processes, it was necessary to map each one using BPMN and then create a specification document outlining all of the required stages and possible error signals.

1.4 Methodology

For the development of the dissertation and the accomplishment of its objectives, it is vital to establish and clearly outline the chosen approach.

In the initial step, the company and the team where this technology is placed were presented. At the same time, the status of the project inside the organization was determined, and the RPA technology, as well as the procedures that had been deployed and familiarization with them, were described.

In the subsequent phase, the next processes to be automated and the method to be adopted for their implementation were specified: meetings with the individuals responsible for the processes, elaboration of the specification documents, submission of the proposals to the partner company, development of the robots, testing, and implementation in a production environment.

At the conclusion of the implementation, the findings were analyzed, and in cases where the implementation was not carried out, the intended outcomes were drafted.

1.5 Structure of the Document

The document is divided into 5 chapters.

The first chapter refers to the introduction: it contains the context and relevance of the theme for the company; a presentation of the company group and more particularly of the business unit where the project was carried out; the project objectives and methodology adopted; and organisation of the document.

The second chapter is dedicated to the literature review of the supporting themes of the dissertation, which aid in understanding the content of this work.

In the third chapter, the already-installed software for the robotization of processes is described, together with the already-established best practices. In addition, there is a part devoted to the overall organization of each process, as well as a brief overview of the existing processes. Finally, the various *to-be-implemented* processes are described, along with their status prior to robotization.

The fourth chapter discusses the analysis performed for each process to determine the optimal solution, as well as the practical implementation of RPA. This chapter utilizes some of the tools created in the preceding chapter. It is also described each phase of the RPA effort, the selected approaches are clarified, an analysis of the costs and payback, and also the achieved results are provided.

The fifth and final chapter provides a summary of the key findings of this project and a few suggestions for further research.

Chapter 2

Literature Review

This chapter brings together the most relevant concepts for this dissertation. It is separated into two distinct sections. The first section focuses on Business Process Modeling and provides a brief overview of four distinct methodologies, being the focus on the Business Process Modeling Notation methodology. The second discusses Robotic Process Automation, including its definition, what requirements a process must meet in order to be automated, the project lifecycle, areas of use for the technology, as well as its advantages and risks.

2.1 Business Process Modeling

Business Process Modeling allows to graphically represent business processes or workflows of a company in a simple and easily perceptible way, facilitating human communication and understanding. In order to understand perfectly what BPM is, it is necessary to define business process. There are various definitions, one of them being "a collection of activities whose final aim is the production of a specific output that is of value to the customer. A business process has a goal and is affected by events occurring in the external world or in other processes" (Caeldries et al., 1994).

BPM creates the theoretical instruments that facilitate the management of organizational processes and their ongoing growth. In addition, its primary objective is to identify potential process enhancements for subsequent implementation. Consequently, BPM represents two states of a particular process: the AS-IS process, prior to the implementation of improvements or potential modifications, and the TO-BE process, following its implementation. Among the numerous benefits, the following should be emphasized: Clear understanding of how all processes in a company function; determination of process interactions and improvement of workflows through the use of graphical representation; creation of more efficient workflows to improve company performance and pave the way for future enhancements; recognition of the need for automation and elimination of redundant processes that waste working time.

Modeling a process generates diagrams and flowcharts that provide vital and comprehensive information on how a certain process operates, such as:

- Actions and events inside a process;
- The person who begins or ends certain actions and occurrences;
- The machinery or equipment used in the procedure;
- The decision points that provide several alternative courses;
- The process's time lines as well as the order of occurrences.

One of the most challenging aspects of business process modeling is the abundance of ways for expressing organizational processes and their requirements (Luo and Tung, 1999). The following is a summary of four BPM techniques:

- **Flow Chart:** This technique is utilized by managers and business owners due to the ease of its graphical depiction, which makes it the easiest to use and comprehend. The sole drawback is that it is not feasible to describe complicated interactions in a single diagram. Hence, Flow Charts are the foundation of BPMN, a technique for displaying complex process flows.
- **Petri-Net:** The Petri-Net technique is more difficult to adopt than Flow Charts due to its restricted number of modeling components. It employs both graphical and mathematical language and is suited for the study and reengineering of business process models.
- **Data Flow Diagram, DFD:** The DFD is an appropriate graphical representation for demonstrating the system's operation. DFD's functional decomposition permits several layers of representation. This method is distinct from others in that it focuses on how data flows through different processes.
- **Business Process Modeling Notation, BPMN:** BPMN is a method based on flowchart techniques that was designed to represent the end-to-end business process and its subsequent transformation into an execution language. This methodology is considered as the most acknowledged for process modeling, which is one of the reasons why it is employed as one of the dissertation's methodologies.

2.1.1 Business Process Modeling Notation

The BPMN technique will now be detailed in further detail, as it was the methodology utilized to conduct multiple process modelling runs, as was previously mentioned. This method is a result of: "an agreement between several companies of modeling tools, which had their own notations, with the purpose of creating a unique and standard language for business process modeling capable of facilitating the understanding and training of the end user"(Entringer et al., 2019). In contrast to other techniques whose original intent was not process modeling, this methodology was developed expressly for process modeling. BPMN may be designed for two distinct levels:

- A more simplistic one, which is reserved for those involved and others interested in a particular process whose objective is to help them comprehend the processes through a visual depiction;
- One that is more tailored to people who will implement the process and provides the relevant implementation-related details.

The BPMN technique is distinguished by its use of a common language to define processes, hence facilitating the technical and non-technical stakeholders' and employees' comprehension. This notation's ultimate objective is to bridge the gap between the process's intended outcome and its realization. This notation was also chosen as the method for modelling processes since it is quite comprehensive and allows operations to be automated simply and rapidly, as well as allowing for model and TO-BE model enhancements (Entringer et al., 2019).

BPMN notation is based on the use of four types of elements:

- **Flow objects:** the individual elements that are contained in this are events, activities and gateways;
- **Connecting objects:** sequence flow, message flow and association;
- **Swimlanes:** pool or lane;
- **Artifacts:** data object, group and annotation.

Flow objects

Events

An event is something that is initiated at a certain instant by a trigger. There are three sorts of events: the Start event, which initiates the process; the Intermediate event, this can be of the type message, error, timer, signal, etc., which happens between the start and end events but does not initiate or finish the process directly; and the End event, which corresponds to the event that terminates the process. They are represented by circles that, depending on the sort of event in question, contain various symbols (Thom, 2006).



Figure 2.1: Types of Events.

Activities

An activity can be carried either by a person or a system. There are activities that are executed on their own, while others are composed of many sub-processes. The "transaction" activity type refers to actions whose steps are interconnected and whose failure leads to the loss of work already

accomplished. Call Activity stands for activities whose global job is repeated. The standard sign for this sort of element is a rectangle with rounded edges, however, there are minor changes based on the type of activity, as seen in the figure 2.2.



Figure 2.2: Types of Activities.

Gateways

Gateways are decision points that permit the splitting or joining of flow objects. The choice is contingent on imposed conditions or events. Gateways may indicate a single alternative (exclusive), depend on a certain event (event-based), provide two path options side-by-side regardless of an event (parallel), etc.



Figure 2.3: Types of Gateways.

Connecting Objects

- **Sequence flow:** As its name suggests, this connection type specifies the flow's order;
- **Message flow:** Represents communications between one process or individual and another that cross "pools" (example in organizations: departments). It should not link activities and events occurring inside the same pool.
- **Association:** Used to link an artifact or text with an event, activity, or gateway.

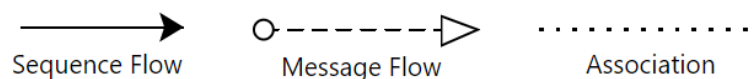


Figure 2.4: Types of Connecting Objects.

Swimlanes

Pool or lane

A pool contains one or more lanes. Each lane symbolizes a person or department in the process being modeled, as well as the actions and flow of that participant. This allows to comprehend the responsibilities of each individual.

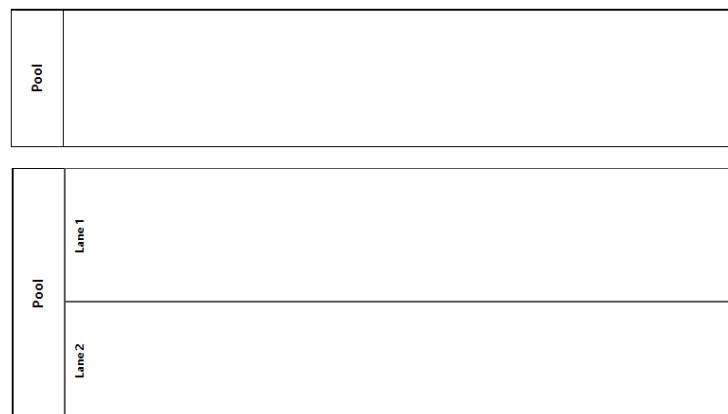


Figure 2.5: Types of Swimlanes.

Artifacts

This sort of elements are mostly used to give information that is not available in the graphic representation but is important for the representation to be complete.

- **Data object:** specifies which data are required for a certain operation or will be generated;
- **Annotation:** clarifies certain elements in the form of an annotation;
- **Group:** represents a collection of activities without disrupting the flow of the diagram.

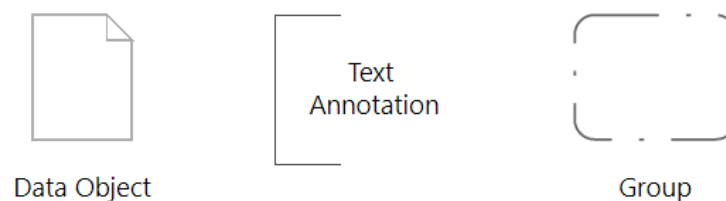


Figure 2.6: Types of Artifacts.

2.2 Robotic Process Automation

Nowadays, automation has altered the current corporate environment. Besides, the possibility of implementing robotic process automation in company processes has been growing rapidly as businesses compete in a digital era that demands flawless operations. With RPA technology, organizations automate non-interactive professional service activities. This technology is a recent innovation with deep roots in BPM.

2.2.1 The concept

As RPA is a relatively new technology, its definition has not yet been agreed upon by all writers, however there is one point on which they all agree: "RPA is a software-based solution" (Willcocks et al., 2015). The core of the RPA concept lies in three terms: robot, process, and automation. The first term refers to programmable software with a specific function, however it is not a real robot. A process is a set of stages that leads to an outcome. In conclusion, automation is the conversion of a manual task into an automated one (Montero et al., 2019). The IRPA-AI Institute gives a definition of RPA that says: RPA is "the application of technology allowing employees in a company to configure computer software or a 'robot' to capture and interpret existing applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems" (Enriquez et al., 2020). In essence, it refers to the automation of traditionally human-performed tasks.

Process automation serves several purposes: (Romao et al., 2019)

- Relieving humans of routine, non-value-adding jobs, allowing them to concentrate on tasks that require their decision-making;
- Enhance outputs quality by making them consistent, exhaustive, and accurate;
- Enable faster task completion by discovering and retrieving pertinent data in the background.

2.2.2 Requirements for RPA application

Not all processes can be automated, thus, the effectiveness of the implementation is strongly reliant on the selected processes. Consequently, a number of literature have been analyzed to determine which requirements must be met in order to automate a process. The specifications are outlined in further detail below:

- High volume of transactions. These type of processes are typically repetitive and routine, making them simple to automate, allowing to maximize the benefits of deploying RPA and get a faster return on investment (Syed et al., 2020);
- High maturity, as automating a process that has not had a period of stabilization might result in disruptions not foreseen when the process mapping is performed;
- A project with little human interaction, guided by rules. It is a good procedure for automation because no decisions must be made by a human;
- Regular access to multiple systems, this are processes that are strong candidates for automation, since repetitive manual system changes can result in increasing human error and expensive costs (Syed et al., 2020);

- Repetitive tasks with a limited amount of exceptions, since if a process has a big number of exceptions, automation, testing, and optimization will take longer;
- Standard. RPA needs every eventuality to be thought through in advance and with rules to follow for each one, which must be unambiguous;
- Error-prone manual processes, due to worker fatigue for example, and rework.

Although not the most popular, it is possible to automate high-value operations with modest transaction volumes. Comparing the cost of business-impacting mistakes caused by a lack of automation with the total cost of automation reveals that the latter has a lower value than the former (ITP, 2013). Figure 2.7 shows the relevance of RPA depending on the different types of cases and their recurrence. Using RPA, the middle section of the curve can be supported by agents that interact with the various information systems as if they were humans.

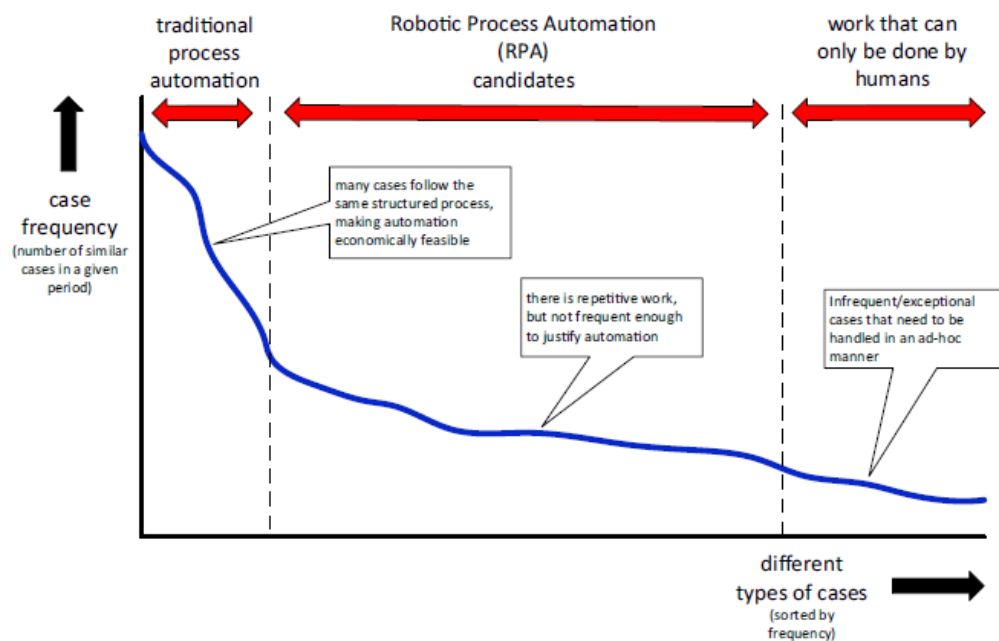


Figure 2.7: Position of RPA.

Source: van der Aalst et al. (2018)

2.2.3 RPA lifecycle

An RPA project must adhere to a six-phase cycle in order to realize robots, represented in the figure 2.8.

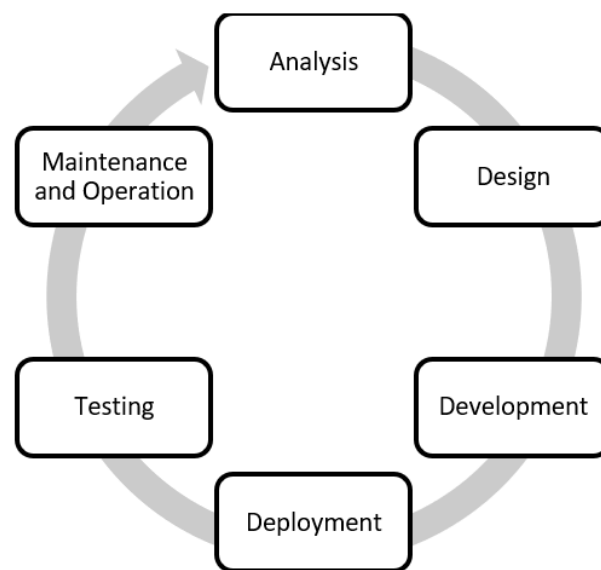


Figure 2.8: Lifecycle of RPA.

Source: Montero et al. (2019)

The primary objective of the analysis phase is to examine and assess the viability of automating a particular process through a comprehensive review of the effort necessary for automation (Enriquez et al., 2020). The processes that were approved in the first phase move on to the Design phase, in which all required process activities, data flows, and operations are detailed. The objective of the Development phase is to implement each of the automatable process components identified in the Design phase. The robots designed and developed so far require an environment to operate, in the context of RPA, this environment is a computer on which one or more information systems have been placed in order for a robot to function. Always operate the robot in its own execution environment. Regarding the testing phase, all robots should preferably be evaluated in a test environment before being deployed in a production setting. Nevertheless, this environment is not always assured, and robots are frequently put in production and subsequently tested to confirm their appropriate operation. Consequently, it is evident that this cycle has a flaw, as the testing stage is conducted directly in the production environment, placing it at risk (Montero et al., 2019). In addition, the purpose of this phase is to monitor and manage the performance of each robot. Lastly, the Maintenance and Operation phase involves keeping the robot operational and resolving any potential faults. During this phase, the performance of the robot in a particular procedure is also evaluated.

To mitigate the issue of testing the robot in a productive environment, the ideal robot development cycle would be the one represented in the figure 2.9. In this cycle, there would be nearly two parallel cycles. The primary cycle is identical to the one described earlier. In the second, there is a platform that replicates the behavior of the actual system with which the robots would interact, which was also discussed earlier. Throughout this phase of robot development, automated testing are conducted (Montero et al., 2019). During the realization of the dissertation, this was the

methodology used during the development of each of the RPA processes.

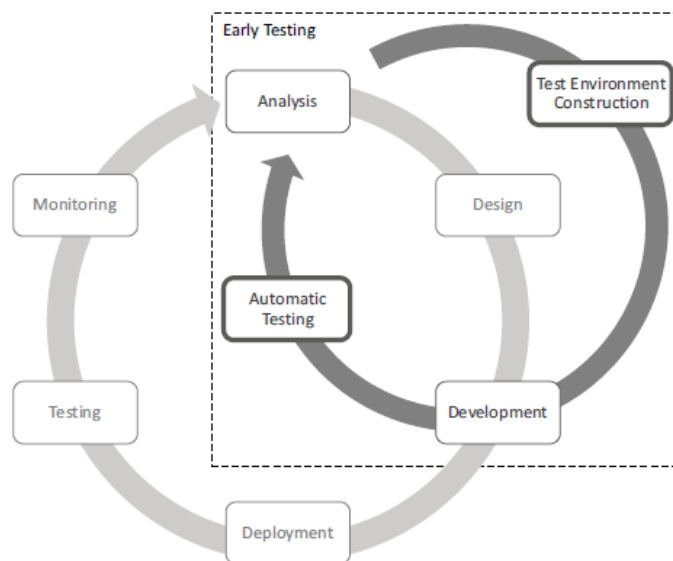


Figure 2.9: Modified Lifecycle of RPA.

Source: Montero et al. (2019)

2.2.4 Areas of applicability of RPA

The characteristics outlined in the section 2.2.2 are not particular to a single function or business sector, nonetheless, there are services that are more susceptible to RPA implementation and have a higher yield.

Finance and Accounting	Human Resource Services	Supply Chain	IT Services
•Sales Order; •Order to Cash (O2C); •Collection; •Procure to Pay (P2P); •Incentive Claim; •Record to Report (R2R); •Supply Chain Vendor Setup; •Trend Tracking.	•Payroll; •Benefits and Compensation; •Pay Slips Management; •Time and Attendance Management; •Recruiting and Onboarding; •Education and Training; •Compliance Report.	•Work Order Management; •Demand and Supply Planning; •Quote, Invoice and Contract Management; •Returns Processing; •Freight Management.	•Installation; •FTP download; •Upload and Back-up; •Server Application and Monitoring; •Synchronizing, Deleting and Emptying Folders; •File Management; •Email Processing; •Batch Processing

Figure 2.10: Areas of applicability of RPA.

2.2.5 Benefits and risks

RPA, being a technological advance is increasingly felt in contemporary communities. It has an increasing number of benefits linked with its deployment, as stated in several literature reports:

- Minimization of reaction times, as the robot can do a task considerably faster than a person;
- Performance enhancement of organizations (Hofmann et al., 2020) as a result of employees executing added value tasks;
- Better archiving of data on the operation of processes and easier tracking of process progress (Holder et al., 2016) are vital for informing decision-making and minimizing IT risks, as well as easing audits and monitoring (ITP, 2013);
- Cost reduction by comparing the cost of installing a robot with the cost of having a person perform the work;
- Limiting the number of individuals with access to sensitive information;
- Reduction of errors;
- More frequent execution of the process, resulting in more recent data;
- Possibility of carrying out the process outside of office hours and peak activity, since robots are operational seven days a week, twenty-four hours a day, as opposed to people whose working hours are around eight hours per day and only on working days (five);
- Increased worker motivation as a result of their incorporation into more rewarding duties requiring critical thinking as a result of the differentiation and complexity of their new jobs;
- Recruitment of individuals with a higher degree of education, as they will be required to perform more complex tasks.

However, there are also problems related to the deployment of RPA that involve the management of human resources: the decrease of Full Time Employees, FTE, might lead to layoffs or retraining of workers, which is not the goal of this technology but is, nonetheless, a possibility (ITP, 2013). In addition, there are legal problems around accountability for robot failures that result in significant corporate losses (Holder et al., 2016).

The prioritizing of jobs to be automated is a challenge since, as the organization applies RPA in a variety of processes, the real advantages become apparent and employee enthusiasm increases dramatically. Another inherent risk is the use of RPA to unsuitable processes, namely those that are excessively complex. This implementation entails significant automation expenses that may be allocated to other, less sophisticated activities. Importantly, there is the possibility of reduced that employee knowledge of specific processes, new audit procedures, and cybersecurity concerns (Anagnoste, 2017). When robots do activities based on erroneous or inefficient methods, they also provide defective and inefficient outputs, resulting in increased expenses and wasteful resource use.

Chapter 3

Initial situation

This chapter will be divided primarily into seven sections, the first six sections will describe the state of RPA at Amorim Cork at the outset of the creation of this dissertation, including the software used, the established best practices, a explanation of the Orchestrator, a description of the organization of each process, the description of the costs model and the processes previously executed. The second part will describe all the processes that were in the pipeline to be implemented, as well as their starting status.

With the 2019 installation of SAP, the number of administrative duties that employees were required to do increased significantly. With time and practice, these duties gradually became repetitious and mundane, yet they remained necessary. Therefore, after a few years and, with the processes having had sufficient time to mature, it was the optimal moment to begin examining the viability of implementing RPA. The RPA project at the company began a year prior to the writing of this dissertation, therefore decisions about software selection and established best practices had already been taken.

This part will cover the original state of the project when arrived at the company, including the selected software, the procedures that had previously been established, the orchestrator's management, etc.

3.1 Software

UiPath was the vendor chosen by Amorim to supply RPA implementation software from the outset of the project. This is a tool that enables the incorporation of RPA capability into its framework for creating and running programming scripts, permitting its programming using a block-based interface and a variety of plugins for customizing business processes. UiPath is the sales leader in this area and it is important to highlight that "15 partners with natural language processing (NLP), intelligent optical character reader (IOCR), machine learning (ML), and chatbots directly integrated with Orchestrator, the central control point, becoming a differentiator from the other vendors" (Clair et al., 2015).

UiPath is positioned among the top 4 software vendors for RPA deployment, as can be seen in the figure 3.1.



Figure 3.1: RPA Magic Quadrant.

Source: Gartner, 2021

3.2 Established Best Practices

The following are best practices in terms of factors to be considered in the project management process definition, which are crucial for the possible development of RPA robots within the company. Essentially, they may be classified into three categories: orchestrator, project management, and programming.

3.2.1 Orchestrator

The following are recommended best practices for the orchestrator: (Macieira, 2021)

- It is crucial that the development and production machines run independently, as the development mode might require production mode operation;
- In the orchestrator, the intended schedule for each process is set;

- There is only one replay of the entire process in the orchestrator. If there are several repetitions for different users, an extra column holding this information should be inserted in the parameterization table;
- The data collected from the parameterization table should be saved in a subprocess so that it is not necessary to reload the data when mistakes occur and reprocessing is conducted. To ease reprocessing, processes should be broken down into subprocesses.

3.2.2 Project Management

The following are recommended best practices for the project management: (Macieira, 2021)

- The primary step in specifying a process is determining whether the robot will execute it record by record or as a whole;
- Exceptions that are uncommon and time-consuming to implement might not be coded into the robot, but rather treated manually;
- The code must be re-used wherever feasible to achieve both the uniformity of procedures and the lowest implementation costs achievable;
- Initially, centralized management for the entire organization is not suggested as it reduces the project's decision-making flexibility;
- The reporting email that notifies of the completion of a process has to include a description of the process and the variables of the process in its body, so that users who get several emails per day for the same process may readily distinguish between each execution;
- It is advised to hire a Business/Functional Analyst to identify the processes for which process mapping and RPA skills expertise are crucial;
- When modifying fields using SAP transactions, it is advised that the modification transaction be used rather than the Consultation transaction and the subsequent change to the "Modify" option;
- It is recommended a standardized framework for the uploading of process-related data and its reporting;
- The robot should only conduct the process when there are work to be completed. If required, a schedule can be created to check out, in a folder, whether there are tasks to be completed;
- When accessible, official systems must be utilized to avoid legal and process disruption issues;
- Including common and possible errors in the specification document makes the process considerably more robust;

- In order to ensure that no modifications were lost, it was deemed essential to include a version history at the beginning of the specification document that provides an overview of each modification;
- In order to execute the process, the SAP variants and layouts have to be accessible to the robot SAP profile;
- The servers and users passwords must be reset frequently, although less often than with regular profiles.

3.2.3 Programming

The following are recommended best practices for the programming of the robot: (Macieira, 2021)

- Whenever moving data from an Microsoft Excel cell to a SAP field, the data must be digitized rather than copied and pasted to avoid field limits from being violated;
- Despite the presence of a dedicated field for layout selection in the SAP transaction, layouts must be chosen from the corresponding menu. This enables for the verification of the layout's presence, since SAP would choose the preconfigured layout for the transaction and not issue a message if the layout indicated in the field was not discovered;
- Prior to every robot digitization of a field, it must be cleansed;
- The SAP and Excel language settings influence the robots' usage of the SAP and Excel selectors;
- After unsuccessfully looking for a selection in SAP for some time, the task ends and produces an error;
- When the information submitted into SAP is excessively long, the field's length must be validated. This is especially important in the area that corresponds to the folder location where the file must be stored;
- When a Menu can occur in several forms, a general principle and an option must be established in the robot's code by establishing a hierarchy;
- It is preferable to export tables from SAP to an Excel file, rather than dealing directly with the information in SAP since, by establishing a static table, it is simpler to reprocess the process in the event of complications;
- Utilizing the character #, allows the recognition of the changeability and dependency on other data of a certain field, including fields from the parametrization table;
- When using SAP, the variant must be picked prior to fulfilling other fields in the SAP transaction, or else, those values will be overwritten if they already exist in the variant;

- In order to avoid the automatic assignment of a hyperlink to the text, in circumstances when email addresses must be entered, it is essential to delete hyperlinks from the parametrization table's field.

3.3 Orchestrator

Amorim has two robots available to perform automated tasks. The platform responsible for controlling and managing the two robots is denoted by the term of orchestrator. When a process has to be completed and one of the robots is already occupied, the orchestrator assigns the new process to the inactive robot, this means, it always attempts to divide the jobs between the two robots in order to maximize profitability.

Each process has a timetable for execution, and the orchestrator delivers the order when the time for execution arrives. When a process does not have a specified requirement to be run, it can be handled in one of two ways: manually through the orchestrator, or by a schedule that checks whether a particular document, such as a Microsoft Excel file, has lines to be processed.

The orchestrator operates using a hierarchical arrangement of jobs and records. One job may have many records, as records are the lines subject to a certain cycle. Typically, each job had a single record. The reprocessing is performed at the record level, while the orchestrator distributes the burden at the job level (Macieira, 2021).

To facilitate possible reprocessing due to errors, all processes are divided into various sub-processes. This split enables for phased reprocessing, that is, if an error occurs in the final part of the process, just the final phase must be reprocessed. Reprocessing can occur outside of the specified schedule.

3.4 General Organization of each Process

Each process has a very similar cloud-based organization in the company's OneDrive, which is accessible from anywhere. Each process has its own folder, which typically has three subfolders: Documents, Parameterisation File, and Execution Reports.

In the Documents folder it can be found: the Process Specification Document, the As Is BPMN model of the Process, and the operations manual. The process specification document is a document that contains all the essential steps to execute the project. This document is needed not only to program the robot and to construct the To Be model, but also to allow any person to execute the process manually if one of the robots is not operating. This folder also contains the As Is BPMN model of the process, which was developed in ".pttx" format. In addition to these two documents, the folder must also contain the Operations Manual developed by the partner company based on the To Be model of each process. This must include the dependencies and needs of each process, in terms of "inputs", "outputs", "target" applications, rules, variations, and expected exception handling, as well as the impact on IT and/or Business if the execution fails.

The process parametrization file is an Excel file and may be found in the folder named Parametrization File. Each process is always accompanied by a parametrization file containing data required during the operation. Typically, the file includes the following columns: User, Variant, Layout, Input Folder, Output Folder and Email. The User column identifies the person responsible for the process and who will be notified when the process is performed and files are produced. The columns Variant and Layout are required whenever the process requires access to SAP; the Variant column functions as the default and filling of particular transaction fields that are wanted to remain constant; Layout functions as the definition of the fields that it is wanted to be displayed, as well as their organization. The Input Folder field gives, if necessary, the path of the folder which contains the file with the data necessary along the process. The Output Folder column specifies the path of the folder where the report generated along the process will be saved. The column email includes the email addresses to whom an email must be sent at the conclusion of the process. In processes where an Adhoc launch is required, the following columns are necessary and added to the file: Adhoc to launch and execution time. In addition, if the processes do not have a specified recurrence, a column indicating the day of the month on which the process must be executed can exist.

Lastly, the Execution Reports folder may vary a little, and the name may not always be the same. However, the idea is the same for all processes, and it is in this folder that SAP exports and reports created throughout the process are saved. Depending on whether it is arranged by user, by company, or by cost centres, the folder may differ slightly.

3.5 Costs Model

To determine the payback and monthly cost of an employee, the data from the table 3.1 was required. The value of an employee's cost per hour and per minute was determined using the company's wage values.

Table 3.1: Costs of Personnel and assumptions of parameters.

Employee Cost/min	0,22 €
Employee Cost/h	13,20 €
Days/month	22
Days/year	227
Hours/day	8
Hours/year	1 816

Equation 3.1 represents the number of hours per month that a worker spends by doing this process manually. Since there are differences from month to month, the number of repetitions evaluated should be an average. For each process, the duration of each repetition should be measured and averaged. However, the exact average time should not be used for calculating purposes, as the following may occur during the execution of the process: mistakes may arise that need

twice or three times the typical time to resolve; repetitive executions of the job generates weariness, which increases its execution time; and so on. Therefore, the time for each repeat must increase by fifty percent relative to the average timed repetition.

$$\text{Monthly Working Hours} = \frac{\text{Repetitions/month} \times \text{Min/Repetition}}{60} \quad (3.1)$$

Equation 3.2 is used to determine the monthly cost of a worker to conduct a process based on the monthly working hours and the cost per hour of an employee.

$$\text{Monthly Cost of an Employee} = \text{Monthly Working Hours} \times 13,20 \quad (3.2)$$

In equation 3.3 is indicated the payback calculation, which is the amount of time required to recoup the initial investment cost. The estimated payback is determined using the monthly personnel cost and the implementation cost of a robot.

$$\text{Payback (months)} = \frac{\text{Cost of Implementation of a Robot}}{\text{Monthly Cost of an Employee}} \quad (3.3)$$

3.6 Processes implemented

At the time this thesis was initiated, the company had already implemented eight processes. The sequence of implementation took into account the availability of the people responsible, the urgency of execution, the complexity and significance of the process, and the involvement of others. The eight processes concern the Logistics, Administrative and Financial and even the Management Control departments and include access to softwares such as Excel, SAP and email. Following is a list of the various processes, along with brief descriptions of each:(Macieira, 2021)

- **Z_Plan Report Execution**, this process is worthy of note for its simplicity and ease of execution. Initially, the process consisted of accessing the *Z Plan* transaction in SAP, selecting the variant and desired layout, and exporting the data to an Excel file. However, it was subsequently expanded to more transactions through the usage of the parametrization file, as the SAP selectors for the numerous transactions were identical. The particularity of this process lies in the information that is constantly being updated, which implies that if a error occurs and reprocessing is required, it may no longer make sense.
- **Closure of Transport Documents**, the need to automate this process stems from the fact that the logistics department is required to close the transport documents. Nowadays, in order to execute this process, the robot must enter the *Cockpit Transport Management* transaction in SAP, choose the desired variant and execute the list of to-be processed documents. Then, it is verified the transportation for each document by clicking a sequence of buttons.
- **VAT Identification Number Validation**, the process consists of, before submitting a VAT return, confirming the VAT identification number of entities linked with intra-community

and national movements. The robot independently performs this verification by accessing the *VIES* website. When the number returns with an invalid state on this site and belongs to a Portuguese company, the robot visits the *Portal das Finanças* website to verify the status of the VAT identification number; if it is active, the status in the report file is updated. The numbers whose status is inactive are forwarded to the person responsible for the process, through email with an attached report file, who clarifies the situation.

- **Purchase Orders Processing**, this process, which was also the responsibility of the Logistics department, performs the placement of intercompany purchase orders. The process of placing purchase orders by the robot consists of accessing a SAP transaction, filling the fields related to the contract with information extracted from the Excel file supplied with the purchase proposal and saving the purchase order, this operation generates the purchase order ID. After the purchase order has been saved, another SAP transaction is accessed by clicking a button, and a message is generated. Finally, accessing a SAP transaction is required to confirm that the sales order was produced in Portugal. Prior to the automation of this procedure, the purchase orders were made individually, automation made it feasible to make them in bulk, which made the process even more efficient.
- **New Orders Update**, the creation of sales orders using the web portal for placing purchase orders contains a reason for refusal. For the orders to be approved, the Customer Service department had to ensure that the fields on the orders matched those in the contracts. The job began to complete this task by comparing the field of the orders with the fields of the contracts. If the fields were identical, the rejection reason (Z0) was eliminated. The robot produces a list of unsuccessful sales orders so that it does not attempt the same validation the next time the process is executed.
- **Bank Extracts Export (MT940)**, in order to complete bank reconciliation, the Administrative and Financial department daily exported the bank statements of about 30 bank accounts distributed to 4 banks. In addition to be in charge of this task, the robot was responsible for uploading these documents into SAP. After uploading each file, the prerequisites for bank reconciliation have been satisfied. Even though the workflow for each of the procedures is the same, each bank has different specifications and behavior when exporting bank statements, therefore the processes are independent.
- **Production Orders Processing**, the department of Management Control was responsible for this process. The production machines are linked to the MES, which supplies SAP with data. When there is no output, various constraints are placed on the operation of the machinery. All production order specifications and actual production order information are exported. When comparing the two values, the disparities are allocated to the orders since the actual values are so far off from reality that it is better to utilize the target values for processing production orders. This procedure seeks to return the lowest possible cost

of orders. After the technical closure of the production orders, the robot corrects these deviations, which was once the controller's responsibility.

- **COGI Correction**, the Production Support department had to fix stock problems caused by counting variations in the factory that were communicated to SAP by MES. To perform the process, the individual records in error are queried in the *COGI* transaction in order to be fixed in the *MIGO* transaction in the future by movements of incoming products. The robot then accesses the *COGI* transaction, picks the corresponding variant for each logistics centre, modifies the record view, and selects the needed layout. Each *COGI*-obtained row must then be adjusted in *MIGO* using stock adjustment movements. At the conclusion, an Excel file of the *COGI* transaction with the modifications performed in the *MIGO* transaction is exported. This report is emailed to the person responsible.

3.7 Processes to be implemented

Prior to the beginning of this thesis, the selection of the following processes to implement had already been made; nevertheless, other initiatives that were not in the immediate pipeline of the company were also developed for implementation. In this part, the many processes that were researched in order to automate are identified and detailed, along with the study conducted to determine the project's viability and the optimal choice. Table 3.2 displays the names of the numerous projects, the department in which they belong, the software utilized, the frequency with which they are conducted, and their level of complexity.

Table 3.2: Processes to be implemented.

Process	Department	Software	Level of Complexity
Loading of Stock In Transit	Management Control	SAP, Excel, Email	Low
Change of Production Order Dates	Logistics	SAP, Excel, Email	Low
Loading of Sales per Day	Management Control	Excel, Email	Very Low
QR Code Reading	Administrative and Financial		Medium
Invoices Accounting	Administrative and Financial	SAP, Excel, Email	
Automatic Entrance of Third Party Merchandise To 100% Sales Party	Logistics	SAP, Excel, Email	Expected to be very low

3.7.1 Loading of Stock in Transit

This process was about to be implemented at the start of this thesis, nevertheless, it will be described and the results will be analyzed as a process to be implemented once the whole process of testing and implementation in a productive environment was followed.

This is not a process that was previously performed by a person, but the introduction of an RPA that performed it generated a substantial return for the company. When products are shipped in SAP from the Portuguese companies to the American sales companies, neither the supply companies nor the receiving companies had access to the shipped stock. The period between shipment

and delivery of products is still substantial and might be as long as two or three months. The only view of the products available was a report including the delivery notes that had been dispatched and were awaiting receipt by the receiving company. On a daily basis, data was processed from SAP into an information data cube, in which the stocks in transit were omitted. This oversight mostly caused logistical difficulties, since there was no document with the orders that had already been shipped.

The purpose of this project was to integrate these stocks, which are not physically located at any Amorim facility but are part of the company's inventory.

3.7.2 Change of Production Order Dates

After the weekly Planning meeting, there are dates for production orders that differ from those that were initially planned. However, the SAP formalization of the new agreed-upon dates is not immediate, since the procedure requires time. This discrepancy in dates prohibits real-time monitoring of loading plans and quota validation in particular families.

Normally, this change of manufacturing order dates was made only on orders with a limited time horizon, this is, orders that had an immediate influence on production. All the others were rescheduled as required due to the workload of the workers. However, this approach did not reflect well on Amorim's planning, as customers expected to get their orders on a particular date and, shortly before this date, were alerted of the date change, when it was formalized in SAP, creating a disruption in their production.

Therefore, although it was not a daily manual task, its automation and increased recurrence brings significant value to the company and is considered an asset.

The execution of the process involved accessing the *CO02* transaction in SAP and updating the *Base-End Date* field with the updated intended date. Depending on the planning models of each order, further actions may need to be taken, however, as they were not the most common occurrences, they were not considered as rules, but rather as exceptions.

3.7.3 Loading of Sales per Day

At the beginning of this dissertation, it was not feasible to view the daily sales of around 30 percent of the companies in the cork stoppers business unit of the Amorim Group, which includes 20 companies, due to the fact that they were not in SAP. Each row of the table 3.3 displays the companies as well as the respective sales volume they represent in the total sales of the group and only within the scope of the project. The companies are sorted in descending order from the biggest sales volume to the lowest sales volume.

Once a month, during the first three to five business days of each month, and using data from the previous month, the only loading of sales was done for each company. This loading was accomplished by receiving around 20 distinct Excel files and then loading the data into the information cubes. The conversion of files to the cube loading format was optimized but not automated,

Table 3.3: Companies out of SAP.

Company	% of Sales	% of Sales of the Project
Christian Bourrasse S. A.	7,5%	25,3%
Trefinos, S. L.	3,9%	13,1%
Industria Corchera, S. A.	3,3%	11,1%
Agglotap S. A.	2,0%	6,8%
Amorim Cork Deutschland	1,6%	5,3%
Amorim Australasia Pty Ltd	1,6%	5,2%
Víctor & Amorim S. L.	1,5%	5,0%
Amorim Cork South Africa	1,2%	4,1%
ACIC USA, LLC	1,2%	4,0%
Korken Schiesser Ges.m.b.	1,1%	3,8%
Corkpack ACI	1,0%	3,4%
Trefinos Italia SRL	0,9%	3,1%
Oller & Cie	0,9%	2,9%
Elfverson & Co., AB	0,7%	2,2%
Sagrera et Cie	0,5%	1,8%
Amorim Cork Bulgaria, EOOD	0,3%	1,0%
Hungarokork-Amorim Zrt.	0,3%	0,9%
Bouchons Prioux	0,2%	0,7%
Corchera Gomez Barris S. A.	0,1%	0,3%
Amorim Cork Beijing Ltd	0,1%	0,2%

which was interesting to happen. The information did not offer daily access to an updated reality every day.

If the process were to be performed manually, it would raise the workload of the worker and the expenses for the company on a daily basis. Since it is a process that can be automated, there was an interest in implementing it using RPA. Although there are implementation and maintenance costs, these would be recovered in a short period of time by the company's increased worth.

3.7.4 QR Code Reading

Initially, this process and the one that will be detailed in section 3.7.5 were presented as a single process, but following a first discussion with those responsible, it became evident that they would be separated into two distinct processes.

Amorim can receive supplier invoices in one of two ways: electronically, as an attachment to an email, or physically, by receiving the document in paper. The process of integrating invoices into SAP is similar for the both types of receiving invoices. However, for invoices that are received physically, they must first be converted into digital format; in the case of electronic invoices, someone must go through all the emails received and save the attachments of each email in a folder.

To convert physical invoices to digital format, identification labels are attached and then scanned. After this step, both electronic and physical invoices are loaded into the *Enterprise*

Scan software. In this program, invoices are organized, and the pages that are truly relevant to be integrated in SAP are picked, this is«, if they contain images as attachments, everything is associated to the same document, and if the invoice has both an original and a duplicate, the latter is excluded. At the end of this organization, the invoices are archived. The next step is to access the *BCC Validation*, an Optical Character Recognition. OCR is a technology that allows the recognition of characters from a scanned, handwritten, or printed image file or bitmap. Therefore, OCR permits the conversion of documents into computer searchable and editable data. The invoices archived in *Enterprise* are imported to *BCC Validation*. In this program, by reading the invoice, the fields: *Vendor No.*, *Company Code*, *Vendor VAT No.*, *Invoice Receiver VAT No.*, *Invoice Reference*, *Document Date*, *VAT Amount*, *Total Amount*, *Currency*, *Purchase Order No.*, *Transport Document* (when applicable) and *Credit Note* (when applicable) are filled in. However, the program's reading and filling of the fields in question does not always provide the proper data, and a person must verify all of the information that the software enters. At the same time, many of the invoices that are received electronically have a QR code that contains information such as *Vendor VAT No.*, *Invoice Receiver VAT No.*, *Invoice Reference*, *Document Date*, *VAT Amount*, *Total Amount* and *Currency*. The combination of the software misreading the fields and the presence of the QR code on a significant portion of the invoices being processed prompted a strong desire to implement an RPA that could read the QR code or fill in the fields with a lower mistake rate.

3.7.5 Invoices Accounting

After receiving invoices and integrating them into SAP, the derivation of the tax code and subsequent posting of the invoice are required. This is a time-consuming and labor-intensive process, which explains the urge to implement an RPA. In addition to the work involved, this procedure is repeated everyday by the different individuals responsible for it, which is another reason why it makes sense to automate the task.

The objective of this process is the accounting of invoices. Each employee has a list of jobs including all the invoices for which they are responsible. The process consists of accessing the transaction */N/OPT/VIM_WP* in SAP. In this transaction, the worker gets access to the list of invoices that fall under his or her responsibility. The next step is to examine each invoice to see if it can be submitted, give the appropriate tax code to each item, and then post the invoice.

3.7.6 Automatic Entrance of Third Party Merchandise To 100% Sales Party

When a client places a purchase order with company B, and company B does not have the items in stock or does not produce them, company B then places an order with company A. In this circumstance, there are two options for shipping and invoicing the products:

- **Option 1:** Company A ships and invoices the merchandise to Company B, and Company B ships and invoices the merchandise to the client.

- **Option 2:** Company A creates a virtual shipment and invoices Company B for the merchandise, while Company B prepares another virtual shipment and invoices the client. In reality, the products have been shipped straight from Company A to the client.

This process relates to option 2, in which it is necessary for company A to give entry of the merchandise to company B so that the latter, supposedly, has stock and consequently is able to invoice the client, when in fact the order was shipped directly from company A to the customer. A required bureaucracy that attempts to remove unnecessary movements of products. The two options are represented in the figure 3.2.

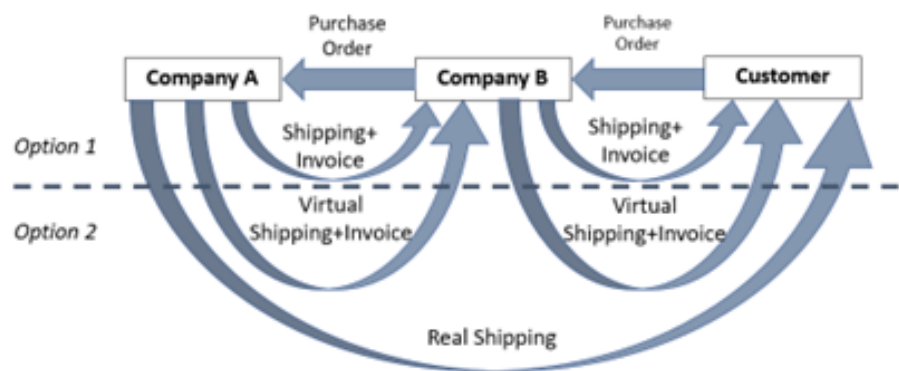


Figure 3.2: Representation of two types of shipment.

The process involves accessing the SAP VL06i transaction, selecting the desired variant, and executing it. Input the supposed delivery date of the merchandise in the Sale company and execute the transaction once again.

Chapter 4

Processes Implementation and Results

In this chapter, the different RPA implementation phases are outlined. There is a section that describes the complete study including questionnaires administered for each process. Also assessed for each process are the expenses with one worker, the cost of deploying the robot, and the expected return on investment. The last part presents the results of the established processes and a brief analysis.

4.1 Global steps for each process

The overall project included the implementation of six different processes and in figure 4.1 is a Gantt diagram, used to control and manage the schedule of the various processes.

Process	01/mar	15/mar	01/apr	15/apr	01/may	15/may	01/jun	15/jun	01/jul
Loading of Stock in Transit									
Change of Production Order Dates									
Loading of Sales per Day									
Bourrasse									
ACDE + ACIC									
QR Code Reading									
Invoices Accounting									
Automatic Entrance of Third Party Merchandise To 100% Sales Party									

Figure 4.1: Gantt Chart.

The architecture of an RPA software consists of three key components:

- The process modelling tool allows the user to replicate human behavior in order to develop a solution;
- The robot, which is the engine of execution that performs the steps described in the development environment;
- The orchestrator, which is the platform that gathers and schedules the created solutions for the numerous robots.

Each of the processes' steps, from specification to implementation to development, are common to all of them. Therefore, in this section, it will be outlined the technological development of a robotic solution, detailing each stage in broad terms and then presenting the details of a specific process.

The first phase entailed meeting with the individuals responsible for each process via Microsoft Teams, allowing the meeting to be recorded. During this phase, the purpose was to become familiar with the process by observing its execution by those responsible. This step is essential because it permits the documentation of all procedures and the identification of any potential exceptions.

In a second phase, the specification document was drafted after multiple views of the meeting's video. It was required to standardize each of the procedures due to the fact that they varied depending on a number of variables. In addition to this, there were always exceptions for which it was required to foresee error messages and the robot's behavior. At the conclusion of the preparation of this document, a new meeting was convened with those responsible for the process in order to receive their approval and discuss any unresolved issues.

After these steps, the specification document was given to the partner organization for appraisal of the process's degree of complexity and the submission of a budget for its automation. The degree of complexity of the operations could be categorized as very low, low, medium, medium high, and high, as shown in **figure 4.1**, based on the estimation of the time required to write the code of the robot, which also impacted the implementation cost. After the analysis of the proposal, it was either accepted or rejected, and the partner firm started the development phase. This step involved the modification of the As Is model and developing a To Be model that was optimized for robot execution.

Table 4.1: Time of Implementation.

Level of Complexity	Time of Implementation (days)		
	From	To	Assumption
Very Low	3	6	5
Low	7	12	9
Medium	13	18	15
Medium High	19	24	21
High	25	40	32

The partner company transmitted a revised version of the specification document containing any outstanding difficulties, but with the process once again streamlined from the perspective of the robot. Amorim reapproved this updated design, and construction of the robot using the To Be model began.

To maintain a smooth development process, it was required to provide test data, access, and credentials for specific software.

After the robot was created, testing were conducted, and any SAP-related procedures were tested in a Quality environment.

Following the conclusion of the testing process, the robot was installed in a Production environment, where it started to be available for usage by a variety of users.

If additional modifications to the automated process were required, they would be considered evolutionary maintenance and would be negotiated based on the process's complexity.

4.2 Process Implementation

After outlining the procedures for implementing an RPA, a more in-depth analysis was conducted for each of the provided projects on the potential issues that may develop and the process definition. This part will address the six processes, the study conducted and the various solutions for each, a more extensive explanation of their execution, and the implementation and manual execution expenses associated with each process.

4.2.1 Loading of Stock in Transit

Prior to the process specification, it was necessary to perform a customisation work to the data received, by developing a *Power Query*. This enables for the extraction, transformation, and loading of data from a particular data source, as well as the automated processing of new data when a new file is received by just pressing the *Refresh* button. With the query, the data in the desired format is obtained and with the fields that are crucial for further loading. The provided designation for the query was *corta e cose*.

The process procedure involves accessing the *VL06i* transaction in SAP and exporting an Excel file with the relevant information from this transaction. Integrate the exported file with the *corta e cose* file, which processes the data. The processed file is stored in a .csv format for later Adhoc posting and loading in Sharepoint, where the stock in transit may be seen. An email is sent, at the end, with an attached report file, confirming that the process has been finished.

The To-Be version of the BPMN model for this process is depicted in the figure 4.2. The To Be model consists of two steps: acquiring tasks and then loading the stock in transit.

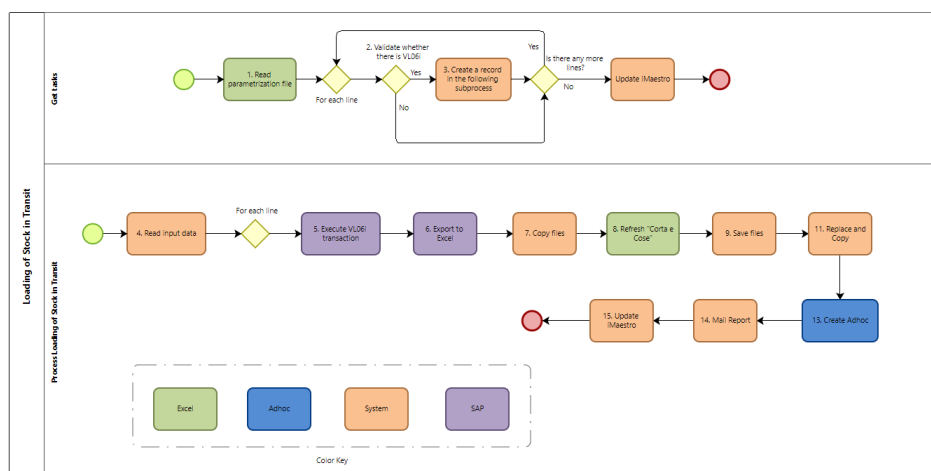


Figure 4.2: To-Be BPMN model of the process Loading of Stock In Transit.

Since the process was not previously performed, it was necessary to estimate the average time required for a load in order to calculate the payback. This estimate was based on the loading time of the Sales per Day process, as the loading procedure is quite similar, with the difference that materials and BPs are loaded on the Sales per Day while just materials are loaded for Stock in Transit. Therefore, the average time considered, taking the time increment into account, was 15 minutes. This process would be conducted every working day, that is, about 22 times each month and for two companies. With these timings, the number of repetitions, and the assumptions described in section 3.5, it was feasible to compute the monthly cost of an employee to conduct this process, as well as the payback period in months. In table 4.2, these variables and the cost of implementing a robot for this process are split down. Despite having a rather lengthy payback period of roughly two years, this method offers more value to the company than can be accounted for due to the possibility of offering a visualisation of the products in transit. Moreover, there are other instances in which it is possible to save money by implementing this process, such as logistical issues related to the omission of products in transit, which cannot be quantified. For these reasons, the decision of proceeding with the process was made.

Table 4.2: Costs and Payback of the process Loading of Stock in Transit.

Monthly Cost of an Employee	Cost of Implementation	Payback (months)
145,2 €	3 636 €	25

4.2.2 Change of Production Order Dates

For the process specification it was necessary to develop rules, due to variances in the planning models for each of the orders. To complete this process, planners supply an Excel spreadsheet with a list of all the production orders whose date need to be modified, as well as the required fields throughout the execution of the task. The robot generates a report based on the given Excel file in which the success or failure of the production order date change for that order is recorded. The first step to access transaction *CO02* remains the same; however, a rule was added for this transaction to alter a field based on the quantity of a given material in order to update the date. Any errors that occur throughout this step are recorded in the report. Then, after filtering the Excel file, the robot imports the file to the *ZPP IMPORT DATES* transaction. It carries out the execution such that the date is also updated in the sales order or stock transfer order, and it registers any errors that occur. At the conclusion of the process, the robot sends an email with the report to the responsible persons.

The To-Be version of the BPMN model for this process is depicted in the figure 4.3. The To Be model consists of two steps, first reading the parametrization file and then processing each row of the file.

To quantify the return on investment of the project, it was essential to determine the average time required to update an order's date, which was around 51 seconds. With a 50 percent increase in the average execution time of each task, the time taken into account was 77 seconds. Each

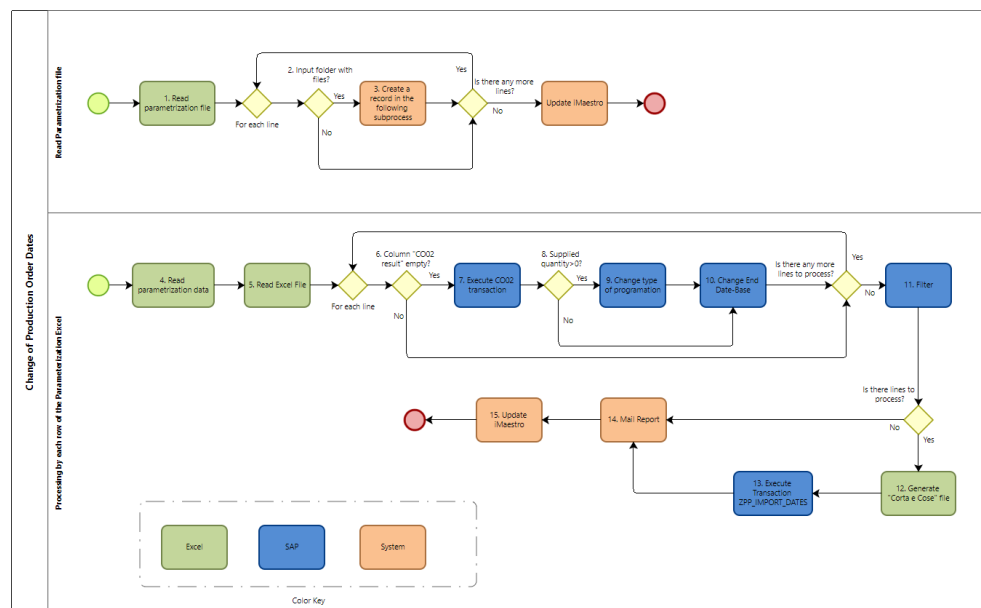


Figure 4.3: To-Be BPMN model of the process Change of Production Order Dates.

week, an average of 300 order changes are requested, which equates to 1200 orders every month. With these timings, the number of repetitions, and the assumptions described in 3.5 it was feasible to compute the monthly cost of an employee to conduct this process, as well as the payback period in months. In table 4.3, these variables and the cost of implementing a robot for this process are split down. Considering the number of hours required for the manual execution of this process, approximately 26 hours, or even its occasional non-execution, the return on investment for this process is fairly reasonable.

Table 4.3: Costs and Payback of the process Change of Production Order Dates.

Monthly Cost of an Employee	Cost of Implementation	Payback (months)
338,8 €	3 636 €	10,7

4.2.3 Loading of Sales per Day

To begin the development of this process it was needed to know what was the reality of each company non-SAP in terms of invoice software, how to access to it, the recurrence of the invoicing, and others. Therefore, an initial survey containing the following questions was conducted to the non-SAP companies:

1. What invoicing software do you use?
2. How do you extract information from the invoicing software?
3. Is the invoicing/management system or any database via the Web or only on the sale's intranet?

4. If only via intranet, do you use a VDI/VPN to access it remotely?
5. In the information associated to your invoice, do you have details of:
 - Cost;
 - Value;
 - Materials;
 - Quantities;
 - Clients.
6. Do you have a weekly/monthly mass invoicing routine or do you invoice daily, at the actual moment when the sale is made?

The detailed results for the survey may be found in the appendix A, however an overview will now be provided. From the initial table 3.3, only 14 companies had answered at the end of the survey. The company Corchera Gomez Barris S. A. ceased invoicing, so was excluded from the scope of the project. The companies: Trefinos, S. L.; Agglotap S. A.; Trefinos Italy SRL; Sagrera et Cie and Bouchons Prioux are all companies of the group Trefinos, which did not answer the survey on time. Regarding question number 1, eight distinct responses were received: Apollo Szoftver, Bravad, Excel, Moware, Myob, Navision, Odoo, and Sage (different versions), with Excel, Sage, and Navision being the most frequent. All answers to question 2 were manual, with the exception of one company that replied Power BI. The responses to the questions 3 and 4 may be compiled: six companies said that the invoicing/management system is accessible online, four said that only via intranet, two responded that the access was possible via VPN, and one responded that the access was possible using Power BI. To answer question 5, all the mentioned fields were included in the invoice details of the companies; however, six companies claimed that the vendor information was missing and two companies noted that the country information was also missing from the invoice details. Since the missing information was no longer utilized to make the monthly sales uploads for these sales, none of the missing fields were considered critical. As for the invoicing practice, more than fifty percent of the companies execute mass invoicing on a daily basis, while one of them performs it biweekly, two companies weekly, one company fortnightly, and another company monthly.

Taking into account the responses of each company, the advantages and disadvantages of each were analyzed, as well as the potential hurdles to surmount. Each company's level of difficulty in delivering the project was estimated based on these variables. The companies in table 4.4 are ranked according to the complexity of their implementation, and the second column indicates the percentage of total project sales that each company represents.

Having stated that, a research was conducted on the current robotization possibilities for each company's process. Exporting the companies' Excel files, processing the data, and finally uploading the processed data into information cubes are required steps to complete this process.

There were two robot solutions identified and are exemplified in the figure 4.4. In the first option, the robot handles the entire process, including exporting the Excel file, transforming the

Table 4.4: Companies included in the project.

Company	% of Sales of the Project	Level of Difficulty
Amorim Cork Beijing Ltd	0,2%	1
Amorim Cork Bulgaria, EOOD	1,0%	1
Víctor & Amorim S. L.	5,0%	1
ACIC USA, LLC	4,0%	2
Amorim Australasia Pty Ltd	5,2%	2
Amorim Cork Deutschland	5,3%	2
Christian Bourrasse S. A.	25,3%	2
Hungarokork-Amorim Zrt.	0,9%	3
Industria Corchera, S. A.	11,1%	3
Oller & Cie	2,9%	4
Corkpack ACI	3,4%	4
Amorim Cork South Africa	4,1%	4
Elfverson & Co., AB	2,2%	5
Korken Schiesser Ges.m.b.	3,8%	5

data, and uploading it to ABBA. The difference in the second option lies in the phase of acquiring the sales Excel file. In this alternative, the file is accessed through a gateway, which eliminates the need for so many robots, provides a more robust solution at a reduced cost to Amorim, and results in a cheaper yearly fee. The optimal approach would be to find a middle term between the first and second possibilities, adopting the gateway option whenever possible and the robot solution if the gateway solution is unavailable. Regardless of the solution, there would always be a substantial amount of customization work and PowerQueries development work required.

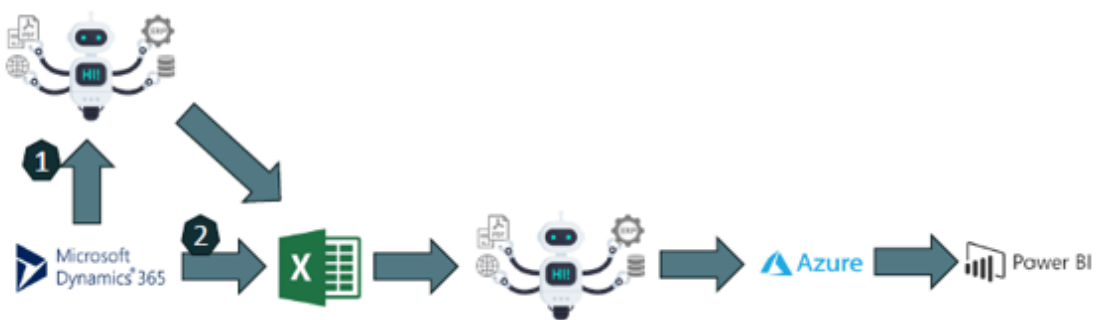


Figure 4.4: Options of robotization.

After analyzing the robotization alternatives, the questionnaire answers, and the sales volume that each company represents within the scope of the project, it was agreed to proceed with Amorim Cork Deutschland (ACDE), ACIC USA, LLC, Christian Bourrasse, S. A. and Industria Corchera, S. A. first. The decision to select Christian Bourrasse as one of the first was based on the company's about 25% of sales. Second, it was agreed to proceed with ACDE and ACIC together due to the fact that their invoicing software was the same, Navision, allowing for the optimization of the tasks to be completed. The company Industria Corchera was also identified as one of

the first to deploy daily sales due to its relatively high proportion of sales out of SAP and not so difficult access to their invoice software.

The approach entailed meeting with the responsible persons of sales of each company and determining how to collect the file containing sales data from the previous day. In the case of ACDE and ACIC, the file could be extracted from the invoicing software and placed straight in a shared folder. In the case of Bourrasse, it was decided that a responsible in this company would send an email with the sales data file attached to the RPA's email account. Then, an automated flow was created with rules whose function is to store email attachments from the given email address to a folder and mark them as read. The attachments to be stored must have the ".xlsx" extension in their name. The automated flow and respective conditions are illustrated in figure 4.5. At the time this dissertation was completed, difficulties with the access to the invoicing software of Industria Corchera were still being resolved.

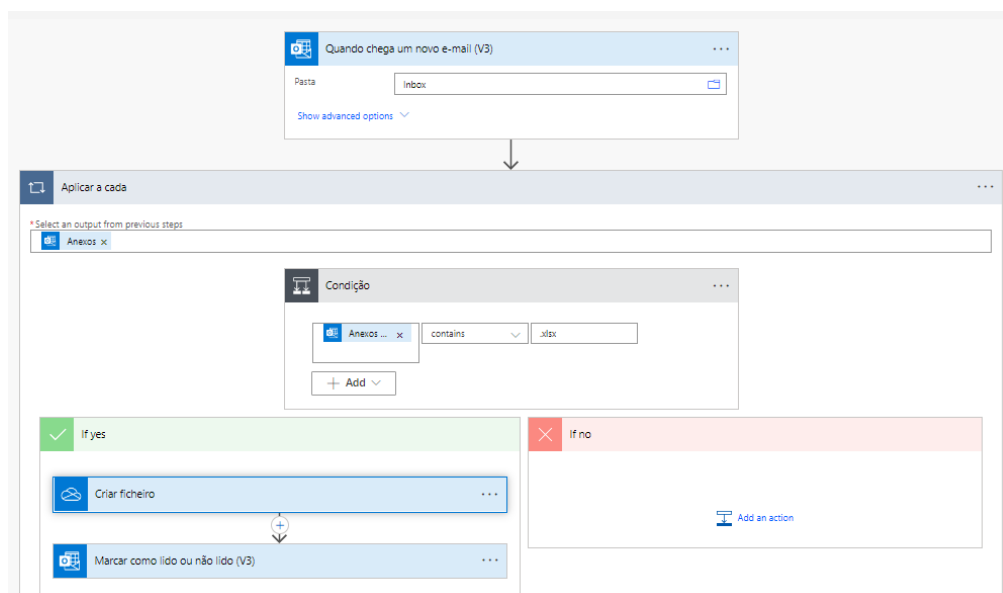


Figure 4.5: Automated Flow to store the attachments.

The subsequent phase involved analyzing the fields necessary to construct the query and providing an Excel file to the companies with a list of the required fields. Before moving on to the specification document, a query was prepared for each company. The query's premise was always the same, but there were slight variations for each company. The intent of the query was to retrieve three CSV files to be uploaded to Adhoc: one containing invoices, another including BPs, and the third containing materials. In addition to these files, three error reports with the same rationale as the CSV files were obtained: one for invoices, one for BPs, and one for materials. The general error report displayed the invoice lines that had unopened BPs and/or materials in SAP. The BP and material error reports contained the information essential to open these elements in SAP. When any of the components produced an error message, the corresponding invoice line could not be posted and was included in the error report. It was important to link the query to the information cubes and Sharepoint in order to determine whether or not each material and BP were open in SAP.

After refining the query, the specification document was prepared. This document was identical for all three companies; what distinguished the processes for each company were the distinctive lines in the parametrization file, which is represented in figure 4.6. The parametrization file can be seen with better quality in the appendix B. In general the process comprises of receiving the file containing each company's previous day's sales data and processing them using the respective query. This final step yields three CSV files that will be utilized to launch an Adhoc: invoices, materials and BP's. Besides the list of the BP's and materials that need to be opened in SAP, a list of errors is also generated. After the files have been produced, the robot independently executes the Adhoc launch. When this is complete, an email containing the three Error Report files is sent to the responsible persons. The responsible party will assess these three files and manually open the materials and BPs in SAP. The next day, while integrating a new file and comparing the error-prone invoicing lines from the previous day, if the cause of the issue has been resolved, the lines are launched again, but with reversion. If, for whatever reason, the process fails in one of the middle phases, the files of that day remain in a folder so they can be reprocessed without the danger of data loss.

A	B	C	D	E	F	G	H	I	J	K
User	Company	Sales Files Folder	Folders of Corte e Corte	Last Errors Folder	Invoices Adhoc Upload Folder	Materials Adhoc Upload Folder	BP Adhoc Upload Folder	Adhoc to launch	Execution time	Email
1	ABO	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\ABO\Ndo Processados	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\ABO\Ndo Processados	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\ABO	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Fat	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Material	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\BP	Order-To-Cash - Futuras	23:00	mario.silva@amorim.com,ana.beatriz.almeida@amorim.com
2	ARI	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\ARI\Ndo Processados	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\ARI\Ndo Processados	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\ARI	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Fat	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Material	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\BP	Order-To-Cash - Futuras	23:00	mario.silva@amorim.com,ana.beatriz.almeida@amorim.com
3	AIHW	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\AIHW\Ndo Processados	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\AIHW\Ndo Processados	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\3 - Relatórios Execução\AIHW	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Fat	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Material	C:\Users\JSESSIONID\OneDrive - Grupo Amorim\IPA - AMORIM CORK12 - Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\BP	Order-To-Cash - Futuras	23:00	mario.silva@amorim.com,ana.beatriz.almeida@amorim.com

Figure 4.6: Parametrization file.

The To-Be version of the BPMN model for this process is depicted in the figure 4.7 and is split into obtaining the tasks and then loading the sales for each company.

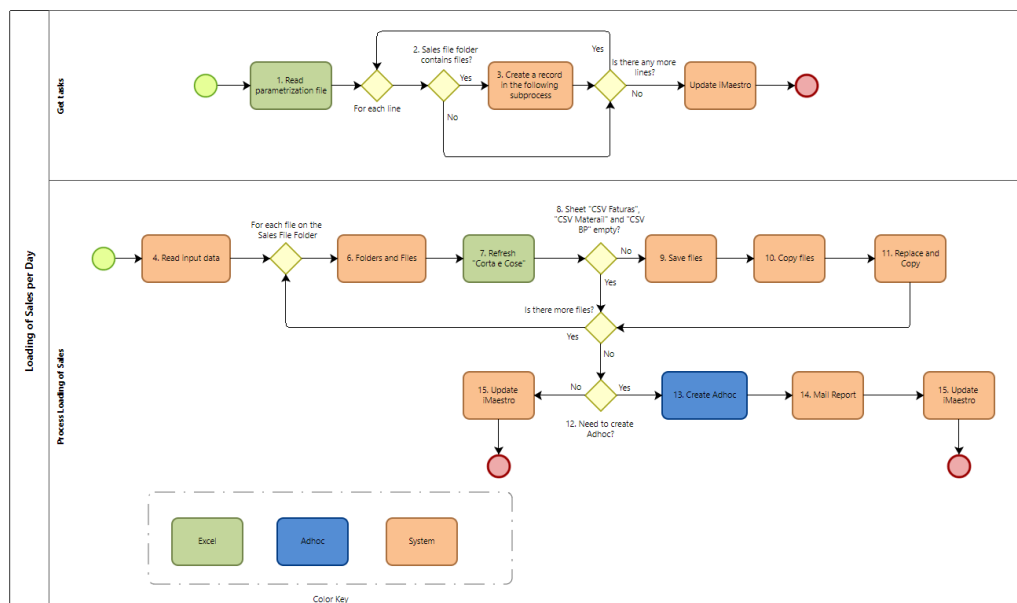


Figure 4.7: To-Be BPMN model of the process Loading of Sales per Day.

For the Payback computation, the loading time of the previous month's sales of the company Bourrasse was measured. The time measured was 20 minutes, however the time utilized for calculations was 30 minutes, due to the required increment. The number of monthly repetitions of this process corresponds to the number of working days in a month, which was considered 22. Table 4.5 demonstrates that the expected cost of integrating the robot was significantly higher than the actual cost for each company. In the cases of ACDE and ACIC, the actual cost of implementation was around one-third of the estimated cost, whereas the disparity was greater for Bourrasse. This difference resulted from the fact that all customization work was performed by Amorim and not the robot developer company, as well as the fact that the data could be obtained through a gateway without the usage of a robot. In addition, the ability to integrate the three companies for the price of a single deployment substantially cut costs. With the timings, number of repetitions, and assumptions outlined in section 3.5, it was feasible to compute the monthly cost of a person to conduct this operation, as well as the payback period in months. In table 4.5, these variables and the cost of implementing a robot for this process are split down. It made sense, in many ways, to implement a RPA for this process given that the financial investment is swiftly reimbursed. It is also imperative to note that any companies that will be included into the process in the future will incur no implementation costs as long as data acquisition, treatment, and transformation are carried out in the same manner. The company Industria Corchera is not considered in the calculations of the project return, since there were access issues to their invoicing software, which were still being resolved, inhibiting the acquisition of sales data, at the time of conclusion of this dissertation.

Table 4.5: Costs and Payback of the process Loading of Sales per Day.

Company	Monthly Cost of an Employee	Expected Cost of Implementation	Cost of Implementation	Payback (months)
Bourrasse	159,72 €	3 636 €	673,3 €	4,2
ACDE		1 818 €		
ACIC				

4.2.4 QR Code Reading

In order to begin the optimization of this process, an automated flow, similar to the one used in the Loading of Sales per Day process, has been incorporated. The function of this flow is to store email attachments to a designated folder and mark them as read. For attachments to be stored, the ".pdf" extension must be present in the attachment name.

In order to implement this process using RPA, several possibilities for filling the fields in the *BCC* were studied:

- **Training mode.** Typically, each supplier has a standard structure for invoices, with defined locations for all the needed information. In the *BCC*, there is a software training

option where you may specify, for each supplier, where on the invoice the required information is located. However, this functionality was not utilized, as a previous conversation with the software's partner in the past indicated that manual training might lead to errors in the global algorithm and in other invoices, hence diminishing the software's overall performance. Therefore, a new contact was made with the partner to determine whether the program had previously evolved and whether the desired feature was already available, the answer was affirmative, however it was decided to include this improvement in the next block of SAP developments. This option does not mean a quick solution to the problem, therefore the study to find the best option was continued.

- **XML Integration.** An XML file is a basic text-based file format for encoding data in the form of hierarchical components, such as papers, books and invoices. With the use of custom tags that identify the kind of element, computer systems are able to comprehend the data contained inside XML files. The XML Integration solution was to directly integrate electronic invoices in SAP using XML, however the invoices that had to be scanned remained problematic. Although it did not totally resolve the issue, it was an option that made sense and that enhanced the process. Consequently, following analysis and discussion with the partner, it was determined that it was viable to immediately integrate the invoices via XML without requiring passing through *BCC Validation*, so establishing an improvement and justifying its incorporation in the next block of SAP development. This integration in the next development block is not a viable solution in the near future.
- **QR Code reading integrated in *BCC Validation*.** The hypothesis of incorporating QR code reading directly into the *BCC Validation* program was also studied. However, after contacting the partner, it was concluded that the functionality would be specific to Portugal and that there would be no possibility of development, at least in the foreseeable future. Therefore, this approach is not a short-term solution to the issue.
- **QR Code reading using RPA.** Since the aforementioned alternatives were not a quick solution, was initiated an approach with the company that develops RPA robots to find a solution and see if RPA was actually the most suitable option. In this contact, several solutions were presented:
 1. **Use of *ZBar image* program to read the QR Code.** The ZBar application is suited for scanning barcodes from a variety of sources, including picture files and even videos. It recognizes several symbologies, including various forms of barcodes and QR codes. It was conducted tests with this software and using different types of invoices. However it was unable to read scanned invoices with a reasonable quality or digital invoices whose QR code was in vector format, which permits limitless zooming without quality loss. In summary, despite its speed, it was incapable of reading both digital and scanned invoices, resulting in a considerable failure rate that made the return less appealing;

2. **Reading the QR Code by accessing web portals**, produced far better results than the prior technique and the website with better efficiency was *Aspose*; however, the reading time was significantly longer, 1 minute for the software and 5 minutes for the web. Considering a daily throughput of 250 invoices, if each one required five minutes to read the QR Code, the robot would be busy for around twenty-one hours each day, in other terms, it would practically occupy a machine permanently;
3. **Invoice processing in both the program and the online site**. In this option, invoices would be verified on the *Aspose* website for those that failed the *Zbar image* validation program. After running several tests, a solution was presented that involved costs associated with the use of *Aspose*, not including the cost of implementing the robot. In this case, direct access to the Web Portal was unnecessary; rather, it would be accessed through an API. API is a system that enables two software components, in this example the robot and the *Aspose* website, to interact via a set of definitions and protocols. In figure 4.8 is an API representation, in which the client represents the robot and the database symbolizes the website. In addition to the additional expense per API usage, this solution's yearly restriction of 72,000 API calls is problematic. Nevertheless, the solution is significantly quicker.

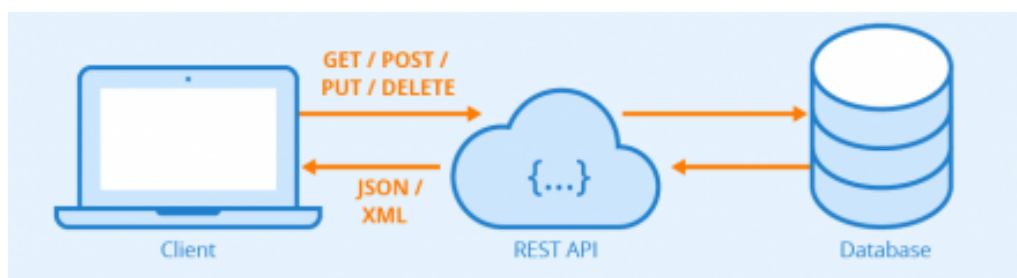


Figure 4.8: API representation.

To determine the project's return, it was essential to time how long it took to read an invoice and correct the OCR's misplaced data. This task was measured and it took roughly 16 seconds. However, with a 50% increase in the average execution time of each activity, the time considered was 24 seconds. Approximately 250 invoices are received daily, which equates to 5 500 invoices each month. With these timings, the number of repetitions, and the assumptions outlined in section 3.5, it was feasible to compute the monthly cost of an employee to conduct this process, as well as the payback period in months. The costs were determined based on the solution in which invoices would first be checked in the *ZBar image* program, and then those that failed the first validation would be sent through the *Aspose* website. In table 4.6, the cost of implementing a robot and the added cost of utilizing 72 000 APIs calls yearly for this process are split out. This process's return on investment has a significantly longer time horizon. However, it should be noted that these values solely account for the process implementation at Amorim Cork, S.A. It is quite simple to

extend the applicability of the process to other companies within the same BU whose execution methodology is the same, hence drastically reducing the payback value.

Table 4.6: Costs and Payback of the process QR Code Reading.

Monthly Cost of an Employee	Cost of Implementation	Cost of Subscription <i>Aspose</i>	Payback (months)
484,0 €	6 060 €	1 800 €	16,2

Prior to the completion of this dissertation, the final decision of picking the best solution had not yet been made.

4.2.5 Invoices Accounting

With the introduction of an RPA, the process would be slightly different, in the sense that the robot would not post all invoices as a person would, due to the robot's inability to handle certain exceptions.

The step to access the transaction */N/OPT/VIM_WP* remains the same, however, in this transaction, the visualization mode is altered and the robot now has access to the list of jobs of all the users accountable for the task. The robot still scrolls over each line of the list, but it will only automatically account for logistic invoices whose purchase order matches the supplier's invoice. The robot compares the purchase order value to the invoiced value, if they are equal, the invoice is processed and posted, otherwise, the invoice reference is gathered and added to a robot's error list. Following the completion of the work list, an email is issued with an attached report providing a list of the invoices that the robot could not post. This would lead in the user's list of jobs including just finance invoices and logistical invoices with balance disparities.

During the process specification, the categorization of the VAT code for each material presented the greatest challenge. This classification was conducted manually by the process responsible who, with years of expertise, did it intuitively based on the material type and supplier. To circumvent this impediment, which merely raises the robot's degree of complexity and hence the related expenses, the potential of classifying VAT codes prior to invoice processing was explored. To this purpose, discussions were conducted and it was determined that the VAT derivation could be incorporated in the pricing determination, a step preceding invoice accounting. The determination of the VAT code per configuration is a difficult process; hence, this determination was relocated to the invoice entry process during the implementation of the SAP project. Adopting a self-invoicing method, which eliminates the invoice scanning and processing steps, is the next step, which is more efficient and was aligned to join the next block of SAP development. Not being an option that solves the problem quickly, it was decided to investigate the robot's classification of the VAT code. In order for the robot to be able to independently classify VAT codes, it was important to develop rules with the process owners and grasp the VAT code derivation decision tree. The fields necessary to obtain the VAT code are the supplier's location (national, EU, or external) and

the material's valuation class. This decision tree does not accurately resolve one hundred percent of derivations, but it does cover the vast majority of occurrences. The two fields necessary are available in the SAP transaction of this process. Using the decision tree, two columns were added to an Excel spreadsheet that must be completed by the robot. The robot must input the nationality of the supplier in the first column and the material valuation class in the second. Excel is programmed to comply to the decision tree's rules. Therefore, for a particular invoice, the robot has access to the VAT code that must be included in each line of materials on the invoice after having filled in the two fields of the excel file.

Currently, five individuals undertake this activity each day, and since 100 invoices with purchase orders are received every day, this results in about 3 300 repeats per month. With these numbers and an incremented average time per invoice processing of 2,25 minutes, table 4.7 displays the monthly cost associated with this operation for the company. There are currently no costs associated with deploying a robot for this process, as neither the specification document nor the related challenges have been resolved, this means the As-Is model has not been delivered to the partner company. On the other hand, this process is unlike others that have been previously developed, making it impossible to quantify its cost.

Table 4.7: Cost of an Employee of the process Invoices Accounting.

Monthly Cost of an Employee
1 197,9 €

4.2.6 Automatic Entrance of Third Party Merchandise To 100% Sales Party

During the initial meeting with those responsible for the process, it was initially intended to apply this process exclusively to Amorim Cork Spain Sale, but because it was performed in bulk by the person responsible, it turned out to be a task without added value that was completed very fast. Therefore, it was questioned whether it might be extended to other companies and also include Amorim Cork France and Italy, so diminishing the project's return on the investment.

For the robot to execute the process, the person responsible must provide an Excel file containing a list of the orders whose products receipt date must be recorded. Based on the given Excel file, the robot generates a report in which the success or failure of the merchandise receipt date entry is registered. The robot accesses the *VL06i* transaction in SAP, picks the desired variant, and executes it, after receiving the file. The transaction is executed again when the required entry date has been inputted. The lines that generate an error are identified in the error report, which is sent by email at the end of the process to the appropriate person. The errors must be corrected by the responsible person in a different way.

At the conclusion of this dissertation, the specification document had not been given to the robots' developer, still, it was able to estimate the cost of executing this method, which was expected to be 2 020 €. This number represents the execution of a process with a very low level of complexity. The basis for considering this value is because the transaction that must be accessed

in order to execute the process is the *VL06i* in SAP, which is also required for the process Loading Stock in Transit. This transaction repetition permits the re-use of the code used to program the robot utilized in the process of Loading of Stock in Transit. In addition to decreasing implementation costs, this reuse enables higher process homogeneity, as outlined in the project management best practices section. The remaining process phases do not significantly enhance the complexity of the process. In the table 4.8 is presented the expected cost of implementation. This value is relatively low due to the simplicity of the process. For the computation of the Monthly Cost of an Employee it was considered that this task required 10 minutes to be done, including the increment. In order for the project's return to be more enticing, the 3 sales were considered for the calculations. Despite the consideration of the three sales for the calculations, it is reasonable to conclude that the payback period is still substantial when compared to the time it takes a worker to perform the procedure manually, around eleven hours. This adds to the uncertainty surrounding whether an RPA will be used to execute the process. At the conclusion of the dissertation, it was unclear if the two companies (Amorim Cork France and Italy) would also be integrated in this project and whether the project would be implemented or not, which is the reason why there is no 100% certainty of the cost of implementation of the process.

Table 4.8: Costs and Payback of the process Automatic Entrance of Third Party Merchandise To 100% Sales Party.

Monthly Cost of an Employee	Expected Cost of Implementation	Payback (months)
145,2 €	2 020 €	13,2

The As-Is version of the BPMN model for this process is depicted in the figure 4.9.

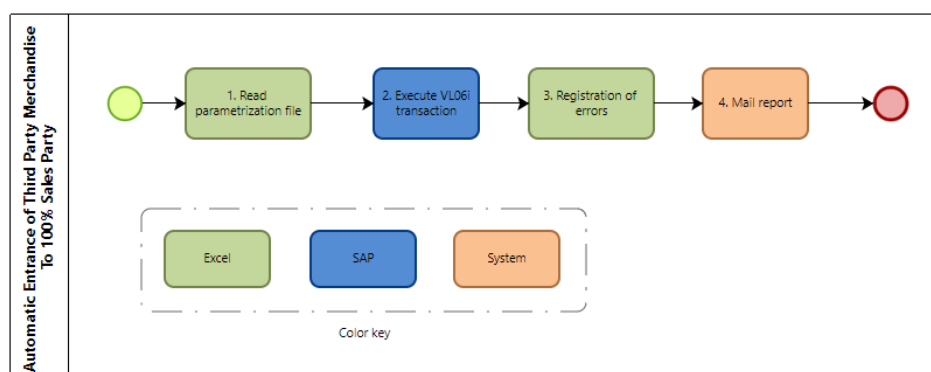


Figure 4.9: As-Is BPMN model of the process Automatic Entrance of Third Party Merchandise To 100% Sales Party.

4.3 Results

The processes are connected to the KPI measuring platform: Elastic after a certain number of days of the robot executing them without any egregious or unanticipated faults. This platform offers three tabs for viewing the KPIs of processes:

- **General Analysis.** At the top of this page are various key fields for analyzing the robot's performance, including the number of processes completed, the number of records executed, the number of hours worked, the number of hours saved from an FTE, and the amount of money saved from an FTE. Below the bar with the displayed indicators are eight different graphics: the first five relate to the number of robot execution hours per business unit, per group of processes (DAF, CG, Logistics, and SP), per robot, per process, and per process/robot; the next two differentiate the efficiency of processes and records, and the final one displays the number of records executed per month and per subprocess.
- **Monthly Analysis.** This page allows the filtration of the displayed data by robot, business unit, process group, process, sub-process, and month. As for the graphics, the majority of them provide the same data as the General Analysis tab, with the exception that they solely pertain to the month being examined, allowing for a better comprehension of the progress of the processes. However, this page contains additional graphics related to the error rate and error messages.
- **Errors Tracking.** In this mode of viewing, the filterable fields are identical to those in the monthly analysis. The presented graphics depict the amount of mistakes, the processes with the highest errors, the error categories, and their progression over time.

Some of the above-mentioned graphs will be presented later through the analysis of results.

Only one of the six procedures mentioned in the dissertation, the Loading Stock in Transit process, was fully completed and implemented. The Change of Production Order Dates process was already in place, but there was insufficient time for stabilization and analysis of the findings. Within days, the Loading of Sales per Day process was prepared for testing in a production environment. The last three, QR Code Reading, Invoices Accounting, and Automatic Entrance of Third-Party Merchandise to 100% Sales Party were either being evaluated or awaiting information required to determine whether to proceed with the project.

4.3.1 General Analysis

Indicators for the nine processes and since the installation of the first process using RPA are displayed in figure 4.10. With 9 implemented processes, the RPA technology has already saved the company around 50 000 euros in FTE. The two robots have already worked a total of 2 265 hours, which is a decrease of about one-third compared to the 3 700 hours that would be spent by a single FTE if it were solely devoted to the nine processes. Considering that there are 227 working days in a year, it was saved around 2 years of work of an employee.

General Analysis		Monthly Analysis		Errors Tracking
21 909	41 083	2 266,5	3 699,5	49 943,65€
Executed Process	Executed Records	Worked Hours	FTE hours savings	FTE costs savings

Figure 4.10: General Analysis.

As can be seen in figure 4.11, the Z_Plan Report export process consumes the most robot time, not owing to the number of steps in the process, but due to the duration of the transaction's execution in SAP. The process that consumes the most time after this one is the New Orders Update.

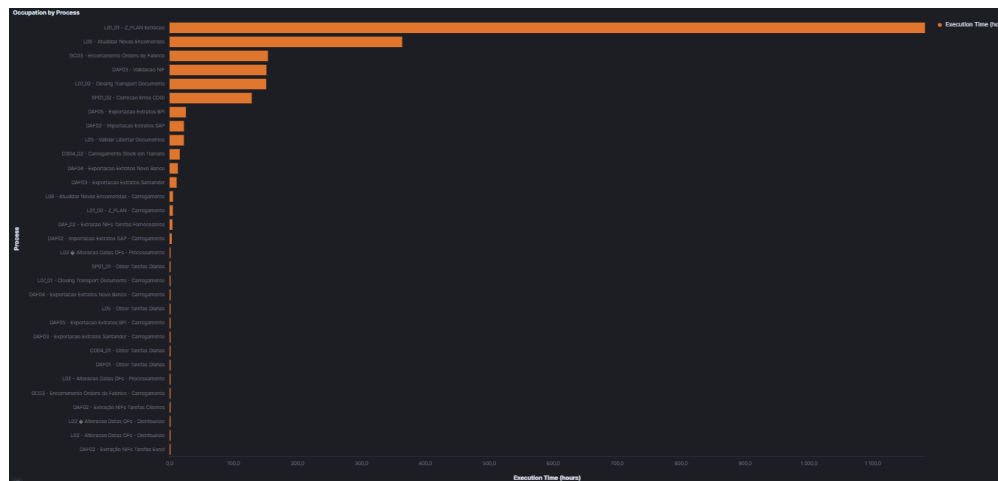


Figure 4.11: Occupation by Process.

Figure 4.12 demonstrates that the Z_Plan report exporting process is the one with the largest number of errors. This superiority in mistake rate may be explained by the presence of a substantial number of process owners, about 30. This number of different owners leads to a substantial number of differences and details in the process, resulting in a large number of minor errors.

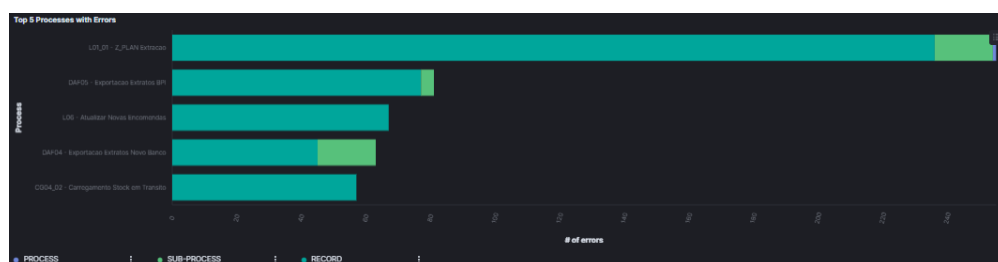


Figure 4.12: Top 5 Processes with Errors.

The overall success rate of the processes, as shown in figure 4.13, is near to 100 percent (99.95 percent), demonstrating the RPA's effectiveness and reliability. The achieved results revealed the applicability and relevance of the technology to the problem, thereby proving that the proposed solution is suitable to the organization.

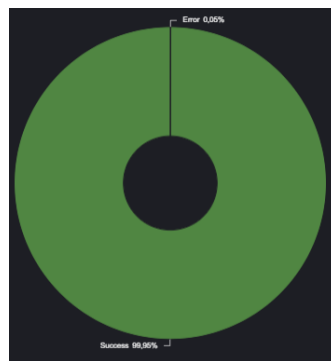


Figure 4.13: Processes Efficiency.

4.3.2 Analysis of the process Loading of Stock in Transit

Only the Loading of Stock in Transit process was applied in a productive context long enough for a time of stability to occur. Consequently, just the results of this procedure will be studied.

For the analysis two filters were used on the platform in the Monthly Analysis view mode:

1. **Period under analysis:** this period was limited to the time frame between the conclusion of the testing phase and the last days working at the company, from March 25 to June 30 of the current year;
2. **Processes' name:** as described in a previous section, the Loading of Stock in Transit process is separated into two subprocesses: Obtaining Daily Tasks and Loading the Stock. The name field was therefore restricted to CG04_01 - Obtain Daily Tasks and CG04_02 - Loading Stock in Transit.

Figure 4.14 indicates the execution of 162 processes, but as the whole stock loading process includes processes CG04 01 and CG04 02, 81 complete stock loading processes were really conducted. Taking into account the 15-minute value of each load, these 81 processes translate into a saving of 41 hours of work of an FTE and and only 15 hours worked by the robot. Already, 555 euros have been saved on FTEs alone.

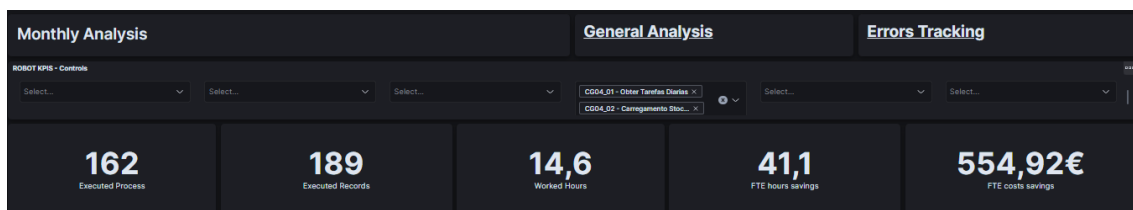


Figure 4.14: Monthly Analysis of the process Loading of Stock in Transit.

Figure 4.15 depicts the robots' occupation per process in terms of execution time, with Stock Loading using more than 95% of the robots' time in this process CG04.

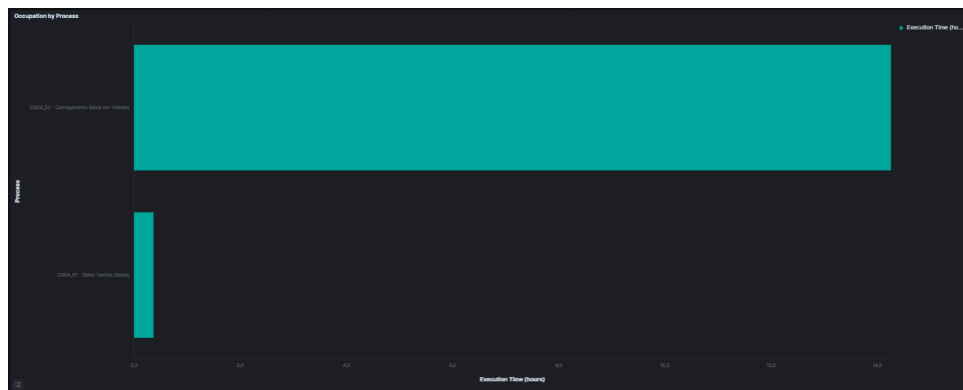


Figure 4.15: Distribution of the Number of Hours of Execution between the Two Subprocesses.

Despite the fact that the process has a certain period of stability, errors still occur occasionally. The majority of errors are associated with the part of the process CG04_02, which relates to the loading of the stock itself (shown in figure 4.16). The errors occur most frequently in the Adhoc launching part, notably with the model and time selections. The Excel file's Refresh All function is another of the most frequent causes for the errors. When these errors occur, the robot halts and sends to the orchestrator a message explaining which error it encountered before continuing with the subsequent processes. To solve this issue, a person merely instructs the orchestrator to restart processing from the point at which it received the error. These errors are not a major concern, as the human solely needs to issue a reprocessing order; they occur because some programs/software (Excel, SAP, Internet) are slower for the robot to do the required click.

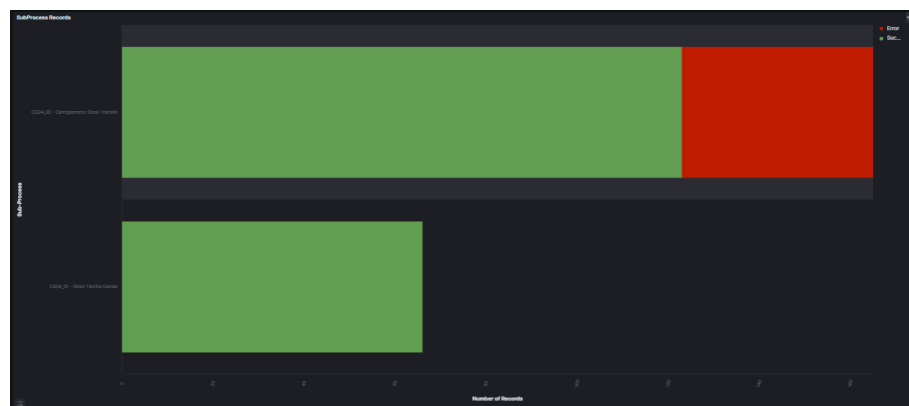


Figure 4.16: Distribution of Errors between the Two Subprocesses.

Chapter 5

Conclusion

This dissertation first aimed to investigate the current literature on BPM, particularly the BPMN technique and the RPA technology. Based on this research, it was determined that RPA is an easy-to-use technology that reduces costs and is straightforward to apply. However, not all processes are suitable candidates for automation; the literature analysis also examined the important aspects.

The initial technological status of the RPA in the company was presented. At the beginning of the dissertation, eight processes had already been deployed. Both the best practices guide and the overall organization principles and automation phases of a process were previously established.

After this explanation, contact was made with those responsible for the new processes that would be implemented. Various sessions were arranged with them to strengthen the acquaintance with the processes and comprehension of possible faults.

Some procedures had features that made their automation difficult and costly, thus discussions began with those responsible for SAP and other programs/software required to execute the processes. For each of these challenges, assessments of the various solutions were conducted to determine which was the most suitable. Following this investigation, the specification document for each process and the As-Is model that incorporates it were created. In addition to these procedures, the viability of each procedure was assessed by comparing the cost of implementing a robot to the monthly cost of having a worker conduct the task. For this to be accomplished it was measured the average duration of each procedure and calculated the monthly cost of a worker. To obtain the implementation cost, the specification document for each process was sent to the robot development company, which provided the cost. This amount was then used to compute the payback. It was also able to estimate implementation costs when portions of the procedures were identical to those already implemented.

After the implementation of the processes, the results were analyzed, including the number of work hours saved and also the saved costs associated with these hours within the project's entire scope and for all previously established processes. In addition, it was determined which procedures required the longest robot time and generated the most processing errors. Furthermore, the error rates for the process implemented during the elaboration of this thesis were studied, as well as the portion of the process where mistakes happened most frequently and also where the

robot spent the majority of its time.

In conclusion, RPA technology enables an exponential increase in process efficiency due to the scalability of the technology, the availability of 24 h daily execution, the speed of process execution, and the reduction of human error as RPA implementation grows and more processes are robotized.

It would be interesting for future projects to utilize the full functionality of SAP and other programs such as *BCC*. This would allow for a greater use and optimization of the processes, reducing the robot's workload and enhancing the robustness of the processes. On the other hand, an expansion of the automated processes to other companies within the Amorim group would be highly intriguing and would allow for a faster return on investment as well as process standardization.

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Appendix A

Results of the survey

Question 1: What invoicing software do you use?

Table A.1: Answers to the question 1 of the survey.

Company	Answer
Amorim Cork Beijing Ltd	Excel
Amorim Cork Bulgaria, EOOD	Excel
Víctor & Amorim S. L.	Excel
ACIC USA, LLC	Navision
Amorim Australasia Pty Ltd	Myob
Amorim Cork Deutschland	Navision
Christian Bourrasse S. A.	Sage X3
Hungarokork-Amorim Zrt.	Apollo Szoftver
Industria Corchera, S. A.	Odoo
Oller & Cie	Sage 50
Corkpack ACI	Unknown
Amorim Cork South Africa	Sage 50
Elfverson & Co., AB	Bravad
Korken Schiesser Ges.m.b.	Moware Software

Question 2: How do you extract information from the invoicing software?

Table A.2: Answers to the question 2 of the survey.

Company	Answer
Amorim Cork Beijing Ltd	Manual
Amorim Cork Bulgaria, EOOD	Manual
Víctor & Amorim S. L.	Manual
ACIC USA, LLC	Manual
Amorim Australasia Pty Ltd	Manual
Amorim Cork Deutschland	Manual
Christian Bourrasse S. A.	Power BI
Hungarokork-Amorim Zrt.	Manual
Industria Corchera, S. A.	Manual
Oller & Cie	Manual
Corkpack ACI	Manual
Amorim Cork South Africa	Manual
Elfverson & Co., AB	Manual
Korken Schiesser Ges.m.b.	Manual

Question 3 and 4: Is the invoicing/management system or any database via the Web or only on the sale's intranet? If only via intranet, do you use a VDI/VPN to access it remotely?

Table A.3: Answers to the questions 3 and 4 of the survey.

Company	Answer
Amorim Cork Beijing Ltd	No
Amorim Cork Bulgaria, EOOD	Online
Víctor & Amorim S. L.	No
ACIC USA, LLC	Online
Amorim Australasia Pty Ltd	Online
Amorim Cork Deutschland	Online
Christian Bourrasse S. A.	Power BI
Hungarokork-Amorim Zrt.	Online
Industria Corchera, S. A.	Online
Oller & Cie	VPN
Corkpack ACI	Online
Amorim Cork South Africa	VPN
Elfverson & Co., AB	No
Korken Schiesser Ges.m.b.	No

Question 5: In the information associated to your invoice, do you have details of:

- Cost;
- Value;
- Materials;
- Quantities;
- Clients.

Table A.4: Answers to the question 5 of the survey.

Company	Answer
Amorim Cork Beijing Ltd	Missing Vendors Information
Amorim Cork Bulgaria, EOOD	Missing Vendors and Country Information
Víctor & Amorim S. L.	Have all of the information
ACIC USA, LLC	Have all of the information
Amorim Australasia Pty Ltd	Missing Vendors Information
Amorim Cork Deutschland	Have all of the information
Christian Bourrasse S. A.	Have all of the information
Hungarokork-Amorim Zrt.	Missing Vendors and Country Information
Industria Corchera, S. A.	Have all of the information
Oller & Cie	Have all of the information
Corkpack ACI	Have all of the information
Amorim Cork South Africa	Have all of the information
Elfverson & Co., AB	Missing Vendors Information
Korken Schiesser Ges.m.b.	Missing Vendors Information

Question 6: Do you have a weekly/monthly mass invoicing routine or do you invoice daily, at the actual moment when the sale is made?

Table A.5: Answers to the questions 6 of the survey.

Company	Answer
Amorim Cork Beijing Ltd	Monthly
Amorim Cork Bulgaria, EOOD	Daily
Víctor & Amorim S. L.	Daily
ACIC USA, LLC	Daily
Amorim Australasia Pty Ltd	Daily
Amorim Cork Deutschland	Daily
Christian Bourrasse S. A.	Biweekly
Hungarokork-Amorim Zrt.	Daily
Industria Corchera, S. A.	Daily
Oller & Cie	Weekly
Corkpack ACI	Daily
Amorim Cork South Africa	Fortnightly
Elfverson & Co., AB	Weekly
Korken Schiesser Ges.m.b.	Daily

Appendix B

Parametrization Document

	A	B	C	D
1	User	Company	Sales Files Folder	Folder of <i>Corta e Cose</i>
2		AIBO	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIBO\Não Processados\	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIBO\Não Processados\
3		AIHI	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIHI\Não Processados\	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIHI\Não Processados\
4		AIHW	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIHW\Não Processados\	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIHW\Não Processados\

Figure B.1: Parametrization Document Part 1.

	E	F	G
1	Last Errors Folder	Invoices Adhoc Upload Folder	Materials Adhoc Upload Folder
2	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIBO\	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Fat	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Material
3	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIHI\	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Fat	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Material
4	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\3. Relatórios Execução\AIHW\	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Fat	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\Material

Figure B.2: Parametrization Document Part 2.

	H	I	J	K
1	BP Adhoc Upload Folder	Adhoc to launch	Execution time	Email
2	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\BP	Order-To-Cash - Faturas	23:00	mario.silva@amorim.com;anab eatriz.almeida@amorim.com
3	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\BP	Order-To-Cash - Faturas	23:00	mario.silva@amorim.com;anab eatriz.almeida@amorim.com
4	C:\Users\##SESSION_NAME##\OneDrive - Grupo Amorim\RPA - AMORIM CORK\12. Vendas ao Dia\TESTAR LANÇAR ADHOC (APAGAR APOS DEV)\BP	Order-To-Cash - Faturas	23:00	mario.silva@amorim.com;anab eatriz.almeida@amorim.com

Figure B.3: Parametrization Document Part 3.