Utrecht University

Graduate School of Natural Sciences
Business Process Management and Analytics

Identifying And Prioritizing Suitable RPA Candidates in ITSM Using Process Mining Techniques

Developing the PLOST Framework

Master Thesis

Hilde Jongeling
Program: Business Informatics

First Supervisor: Dr. ir. X. (Xixi) Lu
Second Supervisor: Prof. dr. ir. H.A. (Hajo) Reijers
Company Supervisor: C.A.J. (Coert) Busio

July 14, 2022

Abstract

RPA is an emerging technology that has as one of the main challenges for a successful implementation the question which candidate to automate.

While different methods exist to identify RPA candidates, they lack in providing objective evidence on why to automate a specific candidate. Objective evidence can be pursued by doing quantitative analysis.

To do this, process mining techniques can be applied to gain insights into the performance of a process. While using this delivers multiple advantages, it is also time-consuming as a great deal of process data needs to be gathered. By adding a qualitative check before the quantitative analysis is applied, time and effort are saved because process mining is only applied to relevant processes.

In order to make an artifact that full fills being both qualitative and quantitative, an extensive literature research has been conducted into existing methods. With the help of a criteria overview and the components of these methods, a framework is developed, the PLOST Framework.

This framework does not only identify suitable RPA candidates but prioritizes them as well into a ranked list. The framework consists of components of existing methods as well as introducing new components. Within the framework, both qualitative and quantitative criteria are used, by adding process mining techniques for the quantitative analysis. The steps of the framework focus on both the high- and low-level of processes, while also taking into account a personalized automation strategy.

A case study was conducted to evaluate the applicability and effectiveness of the PLOST Framework, while thinking-aloud experiments were conducted to evaluate the usability, practicality and completeness. This resulted in adjustments to the framework that were subsequently incorporated into an enhanced PLOST$^+$ Framework but further testing is needed to see how these operate in practice.

Acknowledgements

Conducting this research project was the last component of the master Business Informatics. This means that by finishing the writing of this master's thesis, the end of my study era has arrived. Despite the fact that during this research project I found out I can do more than I think, I could not have completed it all on my own. Therefore, I would like to thank some important people.

First, I would like to thank my supervisors from the university, Xixi Lu and Hajo Reijers, for their guidance, experience, and feedback throughout the project. I am happy that I chose to conduct the project at your research group because of all the friendly people that want to drink coffees.

Secondly, I would like to thank my supervisor from ProRail, Coert Busio. Although the subject was quite new for you, you supported me from the beginning and I appreciate our conversations about how technoloical changes impact the social side as well.

Then I would like to thank my thesis buddies Zoey and Jochem for their (mental) support and celebrating milestones together. The whole project would have been a lot more lonely and boring without you two. I would also like to thank the interviewees and experiment participants for their participation in my research and sharing their knowledge with me.

Lastly, I would like to thank my family, friends and boyfriend for their support and motivation throughout the last couple of months. Especially the latter supported me a lot by checking tutorials and chapters.

Contents

List of Figures

List of Tables

Abbreviations

API - Application Programming Interface
BPM - Business Process Management
BPMN - Business Process Model and Notation
CSD - Central Service Desk
CV - Cumulative Voting
DFG - Directly-Follows Graph
DS - Design Science
DSRM - Design Science Research Methodology
FPSA - Framework for Process Suitability Assessment
FTE - Full Time Employee
IS - Information Systems
IT - Information Technology
ITIL - IT Infrastructure Library
ITSM - Information Technology Service Management
KPI - Key Performance Index
LoD - Level of Detail
OCCR - Operational Control Center Rail
OCR - Optical Character Recognition
P2P - Purchase to Pay
RPA - Robotic Process Automation
RPM - Robotic Process Mining
UI - User Interaction

Chapter 1

Introduction

Digital transformation, the name for technology-based changes within an organization, is nowadays an important topic for companies [41]. It affects large parts of companies and even goes beyond their borders, by impacting business processes, products, supply chains, etc. The potential benefits of digital transformation are numerous, including increases in sales, efficiency or productivity, innovations in value creation, as well as novel forms of interaction with customers. This means companies must evolve digitally to compete with competitors.

One major discipline that powers digital transformation is *Information Technology Service Management* (ITSM). ITSM is focusing on the implementation and management of IT services so they meet the needs of business users [56]. It consists of different processes, such as Incident Management, Problem Management, Change Management, etc.

To ensure a successful establishment, functioning, and maintenance of IT services, companies increasingly benefit from applying an *IT Infrastructure Library* (ITIL)[1] [11]. The application of ITIL deals with a large amount of unstructured textual data, for example in the form of IT tickets related to the incidents, problems or changes in the IT infrastructure products and services [44]. Because of the ever-increasing number of tickets, errors, long lead times, and lack of human resources to process the tickets, correct and timely IT ticket processing is a popular topic among companies practicing ITSM. While small companies still perform the process steps manually, larger companies dedicate big budgets to making their business processes smarter.

Business processes are sequences of well-defined actions that must be modeled and redesigned as needed [1]. Such a process is the activity to accomplish a task completion [40]. In this definition, the difference between a process and a task becomes clear. A process is the essential part of any system or firm and can be executed by things or people or both. It takes inputs per predefined rules to produce the desired output. Despite that, a process is nothing but the steps

[1] `http://www.itil-officialsite.com/home/home.asp`

to go from input to output, but the quality parameters can differ from process to process. Examples of such parameters are the time taken, the number of rework, the number of steps, and the workforce required.

In the context of improving business processes, automation is one of the pillars to fundamentally change the way a company operates, having several cognitive benefits attributed. Among these, the reduction of the employee's workload, a certain level of stability in the execution of a task, the reduction of the occurrence of human errors, and the fact that the operator's additional resources can be allocated to other tasks executed concurrently are the most important ones [13].

Unfortunately, there are also some disadvantages to automation. Over-reliance on automation can make humans less aware of what a system is doing, making it difficult to deal with system failures. Besides that, removing the human from the loop produces significant decreases in situation awareness [46]. Therefore, in an ideal situation, humans and automation are in harmony with each other.

Robotic Process Automation (RPA) is an example of an innovative digital technology that establishes this. RPA is an emerging form of automation for business processes and is seen as an advanced technology in the area of computers science and information technology (IT) [40]. Its main goal is to replace human tasks with a virtual workforce or a digital worker performing the same work as the human worker was doing [17]. It is implemented with the help of a software robot, which imitates the activities of a human employee. This will give the human employee more time to focus on difficult tasks and problem solving, meaning time and costs will be saved on the automated task. Another problem that can be solved with the application of RPA is the lack of human resources a lot of companies nowadays face [40].

Although the word robot may give the vibe of a human-like metal machine, a RPA robot only consists of software installed on a computer. The concept earns the term robot based on its operating principle [9]. That is because a RPA bot is integrated across IT systems via the front-end, while other non-robotic automation communicates with other systems via the back-end. Besides that, RPA is acknowledged as a more lightweight solution that can be rapidly deployed compared to traditional automation, which normally takes a longer period to be implemented [26].

For companies implementing RPA, one of the key challenges is to understand where to deploy RPA [36]. Identification of the right tasks to automate with RPA should be carefully thought of [51]. The reason is that different levels of complexity are involved in the tasks and although humans may easily handle different conditions and applications, learning these steps to a bot should not be underestimated.

By applying an identification phase, the tasks whose complexity could be a stumbling block could be filtered out. Skipping this stage or not paying enough attention to it is one of the main reasons why RPA projects fail or lack behind expectations [52]. But identifying where RPA is highly likely to provide significant value is quite challenging [17]. Therefore, it is strongly required to make use of approaches for identifying the suitable tasks within processes to be automated. This can also help in prioritizing the RPA possibilities, which is another challenge organizations face.

Although some approaches, such as lists of criteria [14] and methods [5, 16, 12, 39], exist to select candidates for RPA, they have several limitations. The first one is that they are time-consuming. Most methods only make use of interviews to understand the process, while this form of data collection and analysis is costly and time-consuming [45]. One method even adds process modeling to this, making the overall method even more time-consuming. Another limitation is that the existing methods focus on either quantitative or qualitative analysis, but not on both. Examples of quantitative criteria for RPA suitability selection are *frequency* and *time reduction*, while *easy data access* and *maturity* are examples of qualitative criteria. Both categories consist of important factors to select on. Therefore, a combination of these two could highly benefit the identification phase. The last limitation is that every method is only focusing on one Level of Detail (LoD), namely either high-level or low-level. The high-level is in this case the process side, where the low-level is the task side. When focusing on only one of these two, the methods lack in giving a full guide how to select a task to automate from a certain process. Therefore, it should not be the question which process or which task to automate, but which task from which process. That is why from now on, there will be talked about candidates instead of tasks or processes in this research. Because of those three limitations in the previous identification methods, it can be concluded that there is a need for formal, systematic, and evidence-based techniques to determine the suitability of candidates for RPA [51].

To provide evidence of a RPA candidate, *process mining techniques* can be used [4]. With process mining techniques, insights into the performance of a process can be extracted from collections of event logs. With those insights, it can be shown how a process is going based on facts, instead of the perception of process experts. This consists of insight into the different tasks within a process, the frequencies of those tasks, variants of the process and waiting times. In addition to the three limitations mentioned above, there is also no selection method available specifically for RPA opportunities in ITSM, while the application offers a range of unused data. Therefore, process mining techniques will be used in this research to provide the quantitative criteria for the candidates.

To solve this research gap, a framework to systematically identify candidates suitable for RPA in ITSM processes is proposed in this research. This is done based on components of existing methods, while using both qualitative and quantitative characteristics and focusing on the high- and low-level. To do this, the data that an ITSM tool generates of business processes is used.

1.1 Research Questions

To answer the aforementioned research gap, the following main research question has been created:

- MRQ: How can process mining techniques systematically be used to identify candidates to automate with RPA within ITSM processes?

With answering this main research question, the goal is to get an overview of the existing methods and their shortcomings, after which it is researched how the proposed framework can fill in these shortcomings with the addition of process mining techniques. Note that because the aim is to involve both processes and tasks in the proposed framework, there is chosen for the word candidates in the MRQ. This question will be answered while making the assumption that data from an ITSM tool is available. To be able to answer this main research question, more insights have to be gained into the previous approaches. Therefore, the following set of research questions has been designed:

- RQ1: How do existing approaches select candidates suitable for RPA and what are the criteria used?
- RQ2: How can the existing RPA candidate selection approaches benefit from the addition of process mining techniques?
- RQ3: What framework can be constructed to select suitable RPA candidates in ITSM processes?
- RQ4: How do experts experience the proposed framework regarding usability, practicality and completeness?

With answering the first research question, the required overview of the previous approaches will be generated. After this, the benefits from the addition of process mining techniques to the previous approaches will be known by answering the second question. To answer the third question, a framework will be designed to select candidate tasks for RPA in ITSM processes. With answering the fourth question, the proposed framework is evaluated.

1.2 Objectives

This research aims to answer the research questions stated in Section 1.1. Besides that, the following objectives have been set for the research:

- Improve the RPA candidate task identification by designing a framework that provides a systematic approach to identify suitable RPA possibilities within ITSM processes.
- Provide the partner organization a framework to select the best suitable candidates to start doing RPA with.

Based on these objectives and the proposed research questions, the following criteria can be set that a framework should meet to fill the research gap:

1. *Systematic* - A systematical framework entails that the framework can be directly used to assess the RPA suitability. This means it is clear which steps need to be executed, what the used criteria are and how they can be assessed, which data is needed and what calculations can be performed. When having a clear structure, it becomes feasible for someone else to perform the framework to get the desired result.

2. *Qualitative and Quantitative analysis* - The framework should use qualitative and quantitative analysis to select candidates that could best be automated with RPA. For both types of analysis, only criteria of that type are used. According to a qualitative criterion only a rank ordering of preferences can be obtained [18]. The value of such a criterion can only be ordered or categorized, which makes it *ordinal.* A quantitative criterion delivers a precise numerical value and is therefore cardinal [18]. By applying quantitative analysis, the framework satisfies being data-driven and evidence-based.

3. *High- and low-level* - The framework should not focus on only the high-level, the process side, or the low-level, the task side, of the candidate selection, but should instead focus on both levels to assess suitability for RPA.

1.3 Thesis Outline

This thesis begins with an introduction of the topic of the research, background information, and the research questions in Chapter 1. Chapter 2 introduces the concepts discussed in this research by the results of the conducted literature research. In Chapter 3, the applied research methodology is explained in detail. Chapter 4 provides an overview of the previous approaches available to select candidates suitable for RPA together with their components and metrics. In this chapter are the metrics analyzed as well to create an overview of all the used metrics. In Chapter 5, the PLOST Framework is proposed, starting with an overview and then going into detail together with the motivation. Chapter 6 shows the results of the case study and the thinking-aloud experiments, together with an evaluation based on which adjustments to the framework are made in Section 6.4. In Chapter 7, the discussion takes place and lastly, in Chapter 8, the final conclusion is given.

1.4 Partner Organization

The partner company in this research is ProRail, the company that manages the Dutch railway network [2]. They are responsible for the maintenance, renewal, expansion, and safety of the Dutch railways. As an independent company they divide the space on more than 7.000 kilometers of rails, they manage

[2] `https://www.prorail.nl/over-ons`

the train traffic en take care of the stations. The Operational Control Center Rail (OCCR) is a partnership of ProRail, rail carriers, and rail contractors. [3]. It coordinates the handling of incidents and calamities on the railways. One of the parties that is located at the OCCR, is the *Central Service Desk* (CSD). The core business of the CSD is solving ICT-related incidents and events. In 2021, there were 25135 incidents at the CSD. Their desk is 24/7 occupied with employees that all have the same skills. Their main ITSM tool is the Marval Service Management System [4], in which they keep track of all the open and closed incidents and events with the use of tickets. The system is referred to as Marval and is not only used by the CSD, but by the whole company. For the definitions of incidents and events, ProRail uses the industry-standard ITIL [5] for ITSM practices. According to ITIL, incidents are defects that have degraded or disrupted services, that are managed so that there is the minimum of business impact [22]. This may not resolve the underlying defect. Events are neither defects nor requests, but actions that are monitored to detect deviations from normal behavior referred to as exceptions.

Within the CSD, automation is not something that is widely implemented yet, but the wish is there to start automating more so that the CSD can do their work more efficiently. Not all systems work as they should, which is a reason for the CSD postponing automation. Besides that, failing automation in the past showed that it can give a lot more work to the employees when they have to resolve the problems failing automation gives, without exactly knowing what the automation script executed. Therefore, the opinions are divided on automation. Everyone knows that it is something that should happen to keep their IT up-to-date.

That is why there is a need for a solution and RPA seems to be a perfect fit for the department, because for RPA is not a problem that some systems do not work as they should and the RPA workforce can cooperate with human employees. That is because RPA is seen as a workaround and not as an infinite solution.

[3] `https://www.prorail.nl/over-ons/wat-doet-prorail/coordinatie-treinverkeer`
[4] `https://www.marval.co.uk/`
[5] `http://www.itil-officialsite.com/home/home.asp`

Chapter 2

Background Literature

This chapter describes the main features of the concepts of RPA and process mining, as well as the link between the two concepts. This is the result of the literature review, of which the methodology has been described in Section 3.2.1. The existing approaches to select RPA candidates are discussed in Chapter 4.

2.1 RPA

RPA is a new technology that makes use of many artificial intelligence and machine learning techniques, such as Optical Character Recognition (OCR), image recognition, etc [40]. RPA can be applied to areas where there are high-volume, repeatable, manual, rule-based, and routine tasks accomplished by the employee [17].

According to [35], a RPA implementation follows in general this lifecycle: (1). Context analysis to determine which processes or tasks are candidates. (2). Design of the selected processes that is going to be developed, including specification of data flow, actions, etc. (3). Development of each designed process. (4). Deployment of RPA robots. (5). Testing phase to analyze performance of each robot and detect errors. (6). Operation and maintenance of the process, including each robot's performance and error cases. The outcome of this stage can enable a new analysis and design cycle to improve the RPA robots.

2.1.1 RPA Elements

RPA consists of three main elements [17]: 1. *Robots*, 2. *Studio*, 3. *Orchestrator*. The three elements and their workflow are illustrated in Figure 2.1.

RPA Robots

The robots, or bots, are the virtual workforce that execute the repetitive and manual tasks. Two different classes of RPA bots can be identified; *attended* bots and *unattended* bots. The first class is designed to work together with human

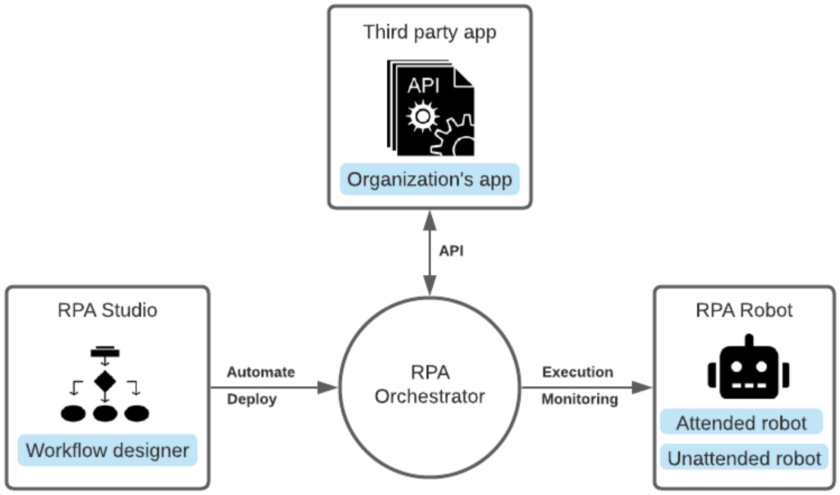


Figure 2.1: The RPA components according to [17].

employees and still need to be triggered by the human user [17]. It can be used to speed up repetitive, manual and highly rule-based tasks where still human intervention is required for the decision points. The second class is, as the name implies, designed to work fully unattended [17]. The bot operates on an organizations's server without requiring the intervention of a human employee and without the need for the trigger of a human user. Instead, it can be triggered by a condition, business event or satisfied event.

RPA Studio

The studio is the designer tool used for the development of the bot scripts. It allows the user to configure the workflow to be executed by robots. It enables users to create, design and automate these workflows. The bots can be programmed by record and screenplay capability and intuitive scenario design interface.

RPA Orchestrator

The orchestrator is the highly scalable control and management server platform and is responsible for scheduling, monitoring, managing, and auditing the robots. As seen in Figure 2.1, the orchestrator connects the studio with the robots and provides a connection that can be used by third-party applications. This is done using Application Programming Interfaces (APIs).

2.1.2 Task Automation

With task automation, the software is used to reduce the manual handling of tasks to make employees more productive and processes more efficient. It can be applied to simple tasks or a series of more complex tasks [34]. Task automation is also called workflow automation.

While task automation and RPA are comparable technologies, RPA digs deeper into a specific type of task, that is performed as part of a workflow [33]. RPA is often used to take data out of one system or document and place it into another. This could be done as well when there is no API available connecting the different systems. Besides that, machine learning techniques can be combined with RPA to make the RPA bot self-learning. This will result in a robot that can learn how to perform automated tasks even more efficiently. Another difference is that because RPA can be applied to a broader range of tasks, it can be used to automate an entire workflow from beginning to end, while task automation is used more specifically for only certain tasks [47].

That does not mean task automation and RPA can not complement each other. Task automation can receive a trigger when a certain RPA task is completed to execute other tasks in the workflow.

2.1.3 RPA Tools

Three common RPA vendors are Blue Prism (founded in 2001), Automation Anywhere (founded in 2003) and UIPath (founded in 2005) [3]. These three are standalone RPA tools, while others, such as Pegasystems and Cognizant, offer RPA functionalities in addition to traditional Business Process Management and Business Intelligence functionalities [51]. In general, the RPA tools include the three different RPA components mentioned before. Besides that, they offer process mining related services as well.

With the all-inclusive licensing model of Blue Prism, you automatically get access to their process intelligence solutions [1]. These exist of process and task mining tools, which can be used to identify, automate, and monitor business processes, and are powered by ABBYY, a digital intelligence company. Besides that, Blue Prism offers a Process Asessment Tool that answers the question what can be automated [2].

Automation Anywhere provides the option to use process mining discovery techniques, to identify how people perform business processes [3]. This is done with their Automation Anywhere Discovery Bot [4]. It observes and records interactions from humans with IT systems to identify automation opportunities and automatically create bots. So where process mining reconstructs processes based on data from event logs, the Discovery bot captures user interactions with any application.

[1] https://www.blueprism.com/products/blue-prism-process-intelligence/
[2] https://www.blueprism.com/products/process-assessment-tool/
[3] https://www.automationanywhere.com/rpa/process-discovery
[4] https://www.automationanywhere.com/products/discovery-bot

UIPath offers three different products in their software as well, to identify processes. These are: Process Mining, Task Mining and Task Capture. UIPath Process Mining [5] can be used to automatically discover the business processes of the organization and understand where RPA would give the most value. The UIPath Task Mining tool [6] is focused on identifying and aggregating employee workflows. After that, AI is applied to identify the repetitive tasks to add to one's automation pipeline. With UIPath Task Capture [7], workflows are recorded to generate process maps. These can then be used for task mining applications.

2.1.4 Benefits and Challenges of RPA

Different benefits can be achieved from the implementation of RPA. The first one is operational efficiency. RPA leads to several operational benefits, under which reduction in time, cost, and human resources, increased productivity, and reduction in manual tasks and workload [51]. The reason for this is that a robot can work 24 hours non-stop, while an average human works eight hours on average. In addition to efficiency, the quality of the service increases with the implementation of RPA. The amount of human errors is decreased, the automated tasks are expected to reach 100% accuracy and common transactional errors are reduced [51]. Because of the constant availability of a RPA bot, reliability and continuity of the service are provided as well. As stated in Chapter 1, compared to other types of automation RPA is cheaper and easier to implement, configure and maintain [51].

Given its young age, RPA implementation still faces many challenges [51]. One of them is the assessment of an organization's readiness for RPA. Frameworks and guidelines assisting organizations to achieve benefits from RPA implementations rarely exist. Besides that, choosing the right activities for RPA is one of the main challenges for successful RPA adoption. This is related to the shortage of frameworks for the whole RPA implementation process. Another challenge is the handling of exceptions in a process. When RPA is applied to a complex process with many variants, the cost of maintaining and servicing the robots could outweigh the benefits of the acquired savings [25]. Therefore, it is crucial to thoroughly understand business processes to make a good decision on which one to automate.

2.2 Process Mining

Business Process Management (BPM) is a discipline all about making operational processes cheaper, faster, and better [23]. Therefore, BPM combines knowledge from IT and management sciences. Although BPM has various benefits, some main limitations prevent companies from using it. The most important one is that BPM systems fail to learn from the event data they collect

[5] `https://www.uipath.com/product/process-mining`
[6] `https://www.uipath.com/product/task-mining`
[7] `https://www.uipath.com/product/task-capture`

[3].

With the advent of process mining techniques, one can extract insights about the actual performance of a process from collections of event logs [4]. Such an event log consists of a set of traces, and each trace itself consists of the sequence of events related to a specific case. Each event in the log refers to at least a case, an activity and a timestamp [3]. Besides that, additional information can be available as well such as the performer, department, cost, etc.

There can be four main types of process mining techniques identified [2]. These different types are:

- *Process discovery.* This process mining task generates process models from event data. It takes as input an event log and produces a process model as output without using additional information.
- *Conformance checking.* This task detects and diagnoses the differences and commonalities between an event log and a process model. It is used to check if the model conforms reality of the data and vice versa. The process model used can be made manual or learned by applying process discovery.
- *Process reengineering.* With this task, the process model is improved or extended based on event data. As input, again an event log and a process model are used, but rather than finding differences, the goal is to change the process model. Updating the models can be used to improve the actual processes as well.
- *Operational support.* When applying for operational support, the process is directly influenced by providing recommendations, warnings, or predictions. It can be executed in real-time, allowing users to act immediately. Therefore, the process is not improved by changing the process model, but by immediately providing data-driven support.

2.2.1 Applications of Process Mining

Various large companies integrated process mining tools and techniques in their business. Vodafone is an example of this. They use process mining techniques to detect process vulnerabilities, it saves time for their process owners to understand where a process fails and it enables them to have real-time analysis of complex processes [8]. A year after the implementation of process mining tools, Vodafone already reduced the cost per process order from $3.22 to $2.85. Also, the percentage of "perfect deals", internal orders done without manual rework, has increased in two years from 73% to 93%.

[8] https://www.minit.io/blog/3-industries-and-companies-doing-process-mining-right

2.2.2 Process Mining Tools

Different process mining tools exist, of which Celonis, Disco, and ProM are common ones. A distinction exists between the tools in whether they are commercial or not. The process mining framework ProM is the non-commercial one of the three and is an extensible framework supporting a wide variety of process mining techniques [21]. The Technical University Eindhoven has developed the tool and is still maintaining it. The other two tools are commercial ones. Both are based on the Fuzzy algorithm [27] with a combination of parts of the Heuristic algorithm. Besides these tools, a wide variety of other commercial tools exist. All these tools can discover Directly-Follows Graphs (DFGs) to show frequencies and bottlenecks. In the tools, the DFGs can be simplified by setting frequency thresholds based on which nodes and edges are removed [2]. With these DFGs, first, the process is discovered before further analysis is conducted.

2.3 Combining RPA and Process Mining

According to the stages of the RPA lifecycle, as described in Section 2.1, process mining can best be applied in the identification, deployment and operation and maintenance stage. This section discusses the benefits of the application of process mining in these different stages.

2.3.1 Identification

The lifecycle of RPA projects starts with the identification phase, in which the processes to be automated are analyzed and selected[35]. The identification of this process should be carefully thought of because different levels of complexity can be involved in tasks [51]. Although humans are good at handling different conditions and applications, it should not be underestimated to learn these steps to a robot. By using an identification phase, the tasks that are too complex can be filtered out. Skipping this stage or not paying enough attention to it is one of the main reasons why RPA projects fail or lack behind expectations [52]. But there is quite a challenge to identify where the implementation of RPA could provide the most value [17]. Not only because this often relies on the study of process documentation, which makes it a time-consuming phase [35]. Therefore, process mining can help in this stage. It can identify promising candidates[3] because the task of discovering RPA possibilities is closely related to Automated Process Discovery, which is studied in the field of process mining [10].

To find out which tasks to favorably automate with RPA, a new class of techniques called Robotic Process Mining (RPM) has been envisioned [38]. It is capable of discovering automatable routines from logs of interactions between workers and Web and desktop applications. The RPM tools take as input logs of user interactions with the applications, which are called *user interaction (UI) logs*. These replace the traditional event logs of traditional process mining techniques. With such a UI log, a RPM tool aims at identifying tasks that could be automated and their boundaries. Besides that, variants of each task are collected, standardized, and streamlined. This helps by discovering an executable specification that corresponds to the streamlined and standardized variant of the task. The identified tasks can be defined in a platform-independent language, which can be compiled into a script to be executed in a RPA tool.

Different methods and tools exist to apply RPM. One of them is SmartRPA, a tool that utilizes UI logs to keep track of routine task executions to generate executable RPA scripts that automate these routine tasks [7]. It is based on the approach presented in [6]. By applying this tool, the manual activity of flowcharts is completely skipped, which results in a less time-consuming and better scalable approach.

Where SmartRPA selects the best observed routine to be generated into a RPA script, the tool Robidium generates scripts based on the most frequent routine [37]. Both these tools are different from commercial RPA tools in the way that they record a UI log to produce a RPA script, while the commercial tools mostly consist of record-and-replay features. Both tools are related to solving the routine discovery problem, which is contrary to this research as it is focusing on the application of traditional process mining techniques.

2.3.2 Deployment

Another application of process mining to the implementation of RPA is seen in the deployment phase, an example is the approach developed by [25]. In this approach, process mining is deployed to help find out the most effective RPA implementation. First, they started with training robots with the existing workflow, while their activities are tracked by the underlying IT systems. After a sound number of executions, the generated process instances are evaluated by using process mining techniques. In this way, the performance of the different robot executions and the human-supported processes are compared to select the best-performing implementation.

2.3.3 Operation and Maintenance

After RPA has been implemented, process mining techniques can still contribute to the successful implementation. At this stage, it can be used to monitor processes and systems, even if these use a combination of RPA bots, human employees, and traditional automation [3]. This can be done by using real-time detection of process changes over time by using process mining techniques [25]. This ensures tracking the impact of the implementation and more importantly, the return on the investment. It can also help to detect when a process evolves in such a way that the robot needs to be adopted to an alternating business environment, reducing the chance of RPA failures.

As can be seen by these examples, in each phase of the RPA implementation the application of process mining techniques can be useful. Therefore, it is important to find out the best way in which one can empower the other. For the RPA identification phase, this research is going to contribute to that.

Chapter 3

Research Methods

This chapter describes and explains how the research has been conducted. To answer the research question of how process mining techniques can systematically be used to identify the most promising task candidates, a framework will be proposed. First, the application of the Design Science Method will be explained, after which an in-depth explanation of the used research methods for the different activities of the Design Science Method will follow.

3.1 Design Science Method

As the Information Systems (IS) discipline is an applied discipline that is oriented to the creation of successful artifacts [42], it is important to conduct research in a structured and guided way. To do so, the Design Science Methodology [32] has been used. Design Science (DS) has been described as the science that creates and evaluates IT artifacts intended to solve identified organizational problems. Such IT artifacts can include models, constructs, methods and instantiations [32]. But it can better be said that it includes any designed object with an embedded solution to an understood research problem [42]. Because in this paper a framework is designed, the Design Science Methodology is in line with the aims of the research.

Although [32] proposes three phases for DS research in IS, [42] elaborates this by developing a methodology with six phases that exist of the combination of the phases from seven different papers. Although this methodology is not the only appropriate methodology to conduct DS research in IS, it is the best fit for this research as the phases are extensive and clearly described.

The six phases that are part of the Design Science Research Methodology (DSRM) are:

1. Problem identification and motivation
2. Define the objectives for a solution
3. Design and development

4. Demonstration
5. Evaluation
6. Communication

The first activity consists of defining the specific research problem and the value of the solution. In the second activity, the objectives of a solution are derived from the problem definition, and knowledge is gained of what is possible and feasible. The next activity is about creating the artifact. In activity four, the use of the artifact is demonstrated with one or more use cases. After that, the results of the demonstration are observed and measured in activity five to see if the artifacts support a solution to the problem. If so, then in the sixth activity the artifact and its context are communicated to researchers and other relevant audiences.

Although there is a sequential order in the phases, there is no expectation that the activities are executed in sequential order from activity one through activity six. Since there was a problem-centered approach needed in this research, there was started with activity one.

Figure 3.1 shows how the DSRM is applied to the steps undertaken as part of this research and the exact order of the steps. In the next subsections, the content of each step will be further explained.

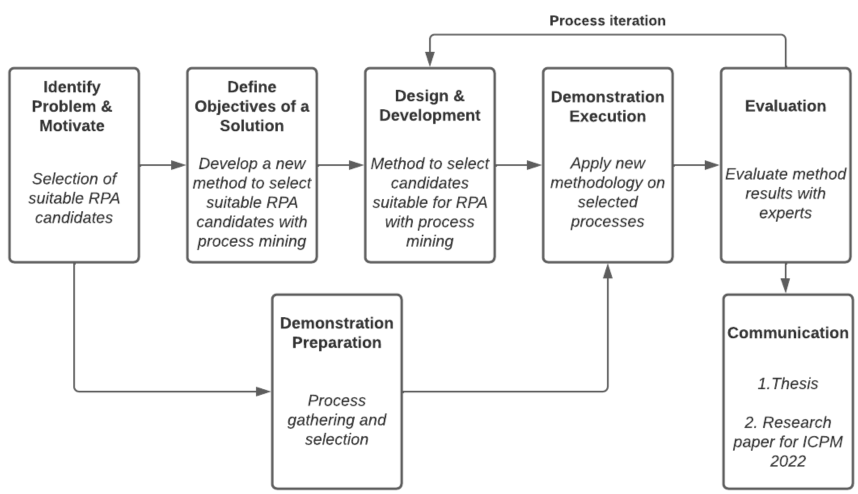


Figure 3.1: The Design Science Research Methodology of the research.

3.1.1 Problem Identification and Motivation

Together with the partner company and the background literature, the research problem is specified. After that, the value of the solution is determined and clear definitions of the concepts used in the research are defined. This is done by conducting literature research on the current state of the problem. The explanation of the conducted literature review can be read in Section 3.2.1.

3.1.2 Define the Objectives for a Solution

In this part, a literature review is carried out as well to give an overview of the existing methods to select suitable RPA processes and tasks. How this literature review is executed can be found in Section 3.2.1. This overview can be used to describe in the objectives what is possible and feasible for the proposed framework. Besides that, it shows what has been researched in this area so far, what different components are used for the suitability assessment, and what the limitations of these are.

3.1.3 Design and Development

In this activity, the proposed framework to select tasks within ITSM processes suitable for RPA with the help of process mining techniques is created, based on valuable components and criteria of the existing methods. These components are assembled to construct the step-by-step architecture of the proposed framework. Besides that, the framework will meet the three criteria set in Section 1.2. Making this framework is done with the help of the literature review of the previous activities, of which the method can be read in Section 3.2.1.

3.1.4 Demonstration

To demonstrate that the proposed framework can be used to solve the sketched problem, a case study with processes from the partner company is set up. The case study is further described in Section 3.2.3. Interviews with domain experts from ProRail are held to collect processes that are inefficient at the moment. The structure of this interviews is described in Section 3.2.2. After the process collection, knowledge about the data availability and data quality of the processes in the ITSM tool is gained with the help of process experts. Based on that analysis, two or three processes are chosen to apply the proposed framework on. This data analysis is done to ensure that process mining techniques can be applied to the processes selected for the research. There will be searched for the event data in the ITSM tool Marval.

For the application of the proposed framework, this framework needs to be designed first. That is why the chronological order of the Demonstration activity is after the Design and Development activity. Since the preparation of the Demonstration takes some time as well and the time is restricted in this research, there has to be started earlier with the preparation of the Demonstration activity. Therefore, this demonstration phase is split up into two activities: the Demonstration Preparation activity and the Demonstration Execution activity. Because enough time should be taken for collecting the processes and gathering information about the available data, this Demonstration Preparation activity starts parallel to the first three activities. After the preparation is finished and the proposed framework is designed, the Demonstration Execution activity starts.

3.1.5 Evaluation

In the Evaluation activity, the results of the framework are observed. For the evaluation, a case study existing of three parts is executed. The explanation of the case study and the different steps can be found in section 3.2.3. When certain steps in the proposed framework turn out that they need to be adjusted, there can be decided to iterate back to the Design and Development activity to try to improve the proposed framework. If due to time restrictions this is not feasible in this research, further improvement is left to consecutive research projects.

3.1.6 Communication

After successfully designing a framework for identifying RPA possibilities in ITSM processes with the help of process mining techniques, the content of this research is not only used to write this Master's thesis but as well to write a research paper. The paper is going to be submitted to ICPM 2022 [1].

3.2 Research Methods

For the development of the proposed framework, three different research methods will be used: 1. A literature review will be conducted to build a theoretical basis for this research and to help designing the method. 2. Interviews will be done to collect processes and evaluate the method. 3. A case study will be executed to evaluate the method. In Table 3.1, an overview of the used methods per activity of the DRSM is given.

3.2.1 Literature Review

According to [53], a methodological review of literature is important to address any research. The literature review in this research consists of two different parts. These are:

- Background literature of RPA, process mining and the link between these two.
- Different methods that select candidates suitable for RPA.

For both parts, it will be described in the next subsections how the literature review has been conducted.

[1] `https://icpmconference.org/2022/`

Table 3.1: Research method per activity of the Design Science Research Methodology of this research.

Activity/Method	**Literature review**	**Interviews**	**Case study**
Problem Identification and Motivation	✓	X	X
Define the Objectives for a Solution	✓	X	X
Design and Development	✓	X	X
Demonstration Preparation	X	✓	X
Demonstration Execution	X	X	✓
Evaluation	X	✓	✓
Communication	X	X	X

Background Literature of RPA and Process Mining

This part of the research aims to provide the reader with a basic understanding of RPA, process mining, and the link between these two. With the help of this fundament, the upcoming parts of the research will be easier to understand. The literature research in this part will be done following the snowballing approach [54], a semi-structured approach. This search strategy has been chosen, as it delivers ample results regarding RPA, process mining, and their link. The initial step of the guidelines of the snowball method consists of selecting a tentative starting set. After that, both forward and backward snowballing are used to collect more articles. Based on inclusion criteria, these articles are either included or excluded. The two inclusion criteria for this part of the literature research are: 1. Articles should feature RPA, process mining, or the link between the two as their main subject. 2. White papers and grey literature are both included. Since RPA is a young discipline and there has not been that much academical research conducted, a multi-vocal literature review will be performed. This means *grey literature* is used as a source of information as well, i.e. blog posts, websites, and papers that are not part of a scientific journal or conference [24].

An initial set has been made for all the three subtopics of this part of the literature review: 1. RPA. 2. Process mining. 3. The link between RPA and process mining. Every set consists of one article for forward snowballing and one set for backward snowballing. The initial set of articles for RPA consisted of [50] for forward snowballing and [51] for backward snowballing. For process mining, the initial set consisted of [4] for forward snowballing and [49]. The last initial set for the link between the two terms consisted of [25] for forward snowballing and [3] for backward snowballing. For the literature search, Google Scholar [2] was used. Only English publications were considered and there was no specific publication date as the research areas of both RPA and process mining are relatively young.

[2] `https://scholar.google.nl/`

The execution of this part of the literature review resulted in Chapter 2.

Different Methods That Select Candidates Suitable For RPA

The second part of the literature review is extracting different methods that select methods that select RPA candidates and their criteria from the literature. This part aims to provide a clear overview of the different methods that exist to select candidates suitable for RPA. For this part, again the snowball method [54] will be employed, meaning the same structure as in the previous section will be used. The initial set of literature will be formed by using the following search terms: "RPA possibilities", "RPA identification method", "process selection RPA" and "task selection RPA". Again, Google Scholar[3] has been used for the collection of literature. Also, the publication dates were not specified and only English publications were considered.

For this part of the literature review, two inclusion criteria have been set. The first inclusion criterion for this part is that an article should provide a concrete selection method or framework, which specifically is meant to be used to select suitable candidates for the implementation of RPA. This can be focused on the high- or low-level of the candidates. The second inclusion criterion is that the article focuses only on the identification phase and is not introducing a complete framework for the implementation of RPA. The reason for this is because this research focuses on methods to select RPA candidates only and complete frameworks do not fit into the scope. Due to time limitations, industrial contributions are left out as well.

The initial search resulted in ten articles. Because some of these articles have conducted extensive literature research, in which dozens of methods have been compared, such an extensive literature research will not be done in this research. The reason for that is that as they already cover the large-scale literature research, all the methods and their metrics have been taken into account in developing the methods. That makes it superfluous to do the same in this study. Instead, the articles that will be selected in this research will be discussed more extensively, looking at the structure of the various components.

After initial screening based on the relevance, the choice has been made to select a method for each level of detail versus analysis combination. These combinations are: 1. High-level, Qualitative. 2. High-level, Quantitative. 3. Low-level, Qualitative. 4. Low-level, Quantitative. In this way, for each level of detail and type of analysis, the different components can be compared. This results in the selection of four articles that are read in more depth.

In Chapter 4, the results of this literature review can be found. This relates to the first research question: *How do existing approaches select candidates suitable for RPA and what are the criteria used?*.

[3]`https://scholar.google.nl/`

3.2.2 Interviews

During this research, interviews are conducted at two activities of the DRSM, these are: 1. Demonstration preparation. 2. Evaluation. In the following subsections, it will be discussed for both activities what the structure of the interviews is and how they are held.

Demonstration Preparation Interviews

The purpose of the interviews in this activity is to collect as many processes as possible, from the CSD of ProRail, that could potentially be automated with RPA. In the interviews, information about the processes was asked from the participants. Beforehand, the idea was to keep the exact subject of the research unknown, to avoid that the interviewees would give answers based on their interpretation of RPA. During the interviews, it became clear that it was not possible to keep the subject unknown, as it would then be too vague for the participants what was being searched for.

All the interviews have been recorded and transcribed. Permission to do this was first requested from the interviewees with the help of a consent form, which can be found in A. All the participants signed this consent form before their interview took place.

The interviews are semi-structured. This type of interview is more flexible than a structured interview and it allows the interviewer to spontaneously react to the interviewee's responses which brings more depth out of the interview [8]. Before conducting a semi-structured interview, a checklist is made up that covers all the relevant areas. The benefit of this method is that it gives the interview some sort of structure while still giving the interviewer opportunities to explore other topics. Since the scope of the processes is not very narrow, there is chosen for a semi-structured interview in this research. This might help the interviewer to collect more processes, which match the purpose of the interviews.

The structure of the interviews in this activity can be found in Appendix B. This shows the global structure of the interviews and the motivation behind these questions and topics. All interviews took place online.

The semi-structured interviews are held with different experts from ProRail, from departments related to the CSD. The inclusion criterion for the experts was that they have a thorough understanding of the business processes at the CSD.

3.2.3 Case Study

After the framework has been designed, it will be tested through a case study. In DRSM, a case study can be used to evaluate the designed artifact in a realistic business environment [42]. The goal of the proposed framework is to select candidate tasks suitable for automation with RPA out of business processes. The case study exists of three parts: 1. Demonstration of the framework by the researcher. 2. Think-aloud experiment. 3. Implementation of a RPA automation.

Demonstration of Framework by Researcher

The first part of the case study exists of the demonstration of the proposed framework by the researcher. This will take place at the partner organization, that has currently this business use case. The case consists of the demonstration of the steps that will be part of the designed framework. For this demonstration, a data set will be build, that is reused for the thinking-aloud experiments. The goal of the case study is to test the applicability and effectiveness of the framework. Applicability is understood as whether the different steps of the proposed framework can be applied to an industrial use case. Effectiveness is the extent to which an artifact fulfills its objectives without incapacitating its means and resources [43]. This means that effectiveness reflects back to the objectives in Section 1.2, and tests as well whether the output can be automated with RPA.

Thinking-Aloud Experiment

The second part of the case study exists of a thinking-aloud experiment. During a thinking-aloud experiment, participants are encouraged to express out loud what they are looking at, thinking, doing and feeling, while they perform certain tasks [28]. In this way, the thoughts, feelings and opinions of the participants becomes clear, regarding the tasks. According to [55], thinking-aloud methods are being used more and more for evaluation and are plausible candidates for this role. This is because the usability, feasibility and repeatability of the designed framework can be proved.

For the thinking-aloud experiment in this research, two participants will be observed; one who is an RPA expert and one who is a domain expert. The researcher will give the participants a clear tutorial of the framework they have to execute. Besides that, the researcher will provide them criteria to criticize each step of the framework on. With this instruction, the participants are asked to execute the framework and think out loud when working. To evaluate the designed framework, the participants will receive the same data set as that was used in the case study of the researcher. In this way it can be checked if the framework is clear enough to provide the same output when executed by different users.

The goal of the thinking-aloud experiments is to test the usability, practicality and completeness of the framework. Usability is described by [57] as the extent to which an artifact can be used by specified users to achieve specified goals in a specified context of use. When having this in mind, it means for this research that the participants of the thinking-aloud experiments can use all the components of the proposed framework. Practicality is seen as how executable the framework is for the participants. Lastly, completeness is interpreted as that nothing is missing. In this research that means that the different components of the framework are complete and do not miss any information.

Implementation of RPA

If the output is the same for the first two parts of the case study, the most suitable business task will be automated with RPA. The automation of this task will be implemente

After the demonstration and the thinking-aloud experiment result in the same task that is suitable for RPA, an example RPA solution will be implemented at the CSD. Due to time limitations, it is not possible to develop a RPA bot that is ready for complete implementation into the systems. That is why it is decided to implement an example solution in a test environment as a replacement. With the outcome of this experiment, it will become clear whether the output of the framework is suitable for automation with RPA or not. Besides that, the experiment will say something about the possible results in relation to the business values. When for example the automated task was chosen because of its considerable time savings, it can be proved whether this is the case after implementation or not.

Chapter 4

Related Work – Identifying RPA Candidates

The goal of this chapter is to give an overview of the existing methods to select candidates that can be automated with RPA, such that the first research question can be answered. This chapter is the result of the conducted literature review that is explained in Section 3.2.1. As explained in that section, the different methods discussed in this chapter have been selected based on their level of detail versus analysis combination. Since these methods consist of valuable components, they are used as building blocks for the proposed framework.

For each method, a short introduction is first given, after which the exact steps of the research are discussed in more detail. Then, the benefits and limitations are considered regarding the possibilities in this research. Each section will end with an analysis of the method regarding the set criteria for method analysis discussed in Section 1.2. At the end of the chapter, an overview is given of all the discussed methods.

4.1 Overview of the Discussed Methods

This section discusses four methods that can be used to identify RPA candidates. As explained in Section 3.2.1, these methods have been selected based on their level of detail versus analysis combination. Table 4.1 shows an overview of the four discussed methods and which criteria they meet from Section 1.2. As can be seen, none of the methods meets all three criteria, and it was also found that none of the methods from the initial set of the literature study discussed in Section 3.2.1 did so. This proves there is room to improve the existing methods by designing a new method that systematically combines qualitative and quantitative analysis for both high- and low-level.

Table 4.1: Overview of all the discussed methods and if they meet the criteria.

#	Method	Systematic	Type of Analysis	LoD
1	The RPA Suitability Framework [5]	✓	Qualitative	High
2	Framework Using Process Mining for Discovering RPA Opportunities [29]	✓	Both	Low
3	Candidate Tasks Selection Approach for Automation with RPA [16]	✓	Quantitative	Low
4	The Framework for Process Suitability Assessment (FPSA) [49].	✓	Quantitative	High

4.2 Method 1: The RPA Suitability Framework

Introduction Method

One of the approaches to select RPA candidates, is the RPA Suitability Framework [5]. It is a five-step approach, which includes the use of the Business Process Model and Notation (BPMN) to model processes. The framework can be found in Figure 4.1. The RPA Suitability Framework is based on the collection of criteria from 23 different literature resources. This yielded 49 criteria, after which criteria that were almost identical were grouped together. After analyzing the results, six mandatory criteria were kept in the framework.

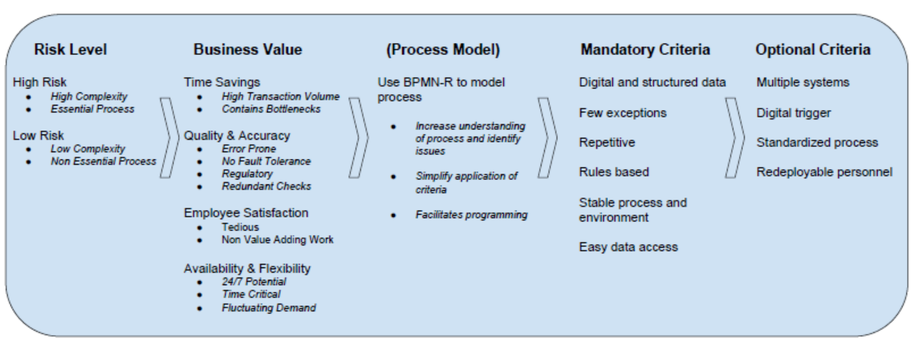


Figure 4.1: The Suitability Framework designed by [5].

Explanation Method

The five steps should be executed in the order they are visualized. It works as a funnel, meaning that the first step includes many processes, and each next step filters out some processes. In this way, in the end only the candidate processes are leftover.

In the first step, the risk of automating the process using RPA has been decided. This is based on two main factors: process complexity and process importance. A high risk level is given to essential processes that are complex and a low risk level is given to non essential processes with low complexity. A mix of the two factors is possible as well but it makes the risk level harder to determine. A high risk level does not mean the process has less potential to be automated with RPA, as it depends on the organization how much risk they are willing to take. Therefore, the goal of this step is to align the organization's automation strategy with the risk level of the processes. If there is no alignment, processes can be omitted.

The next step focuses on the business value of the process. This step comes prior to the detailed investigation of the process, as the authors say there is no need to spend resources on automation if the process would not achieve a clear business value. In order to have business value, the process needs to have potential value in one of the following categories: *Time Savings*, *Quality & Accuracy*, *Employee Satisfaction*, or *Availability & Flexibility.* When this is met, the process proceeds to the next step. The category *time savings* applies to processes that are performed often, take a lot of time to perform or have bottlenecks. In these cases, automation can lead to an increase of the throughput time. The category *Quality & Accuracy* applies to processes with multiple cases of rework or rejections and delays because of these. By applying RPA, the quality raises which make the need for quality checks reduced or even removed. The category *Employee Satisfaction* is obtained by a workforce that is doing meaningful and value-adding work. An important factor is that the employees are redeployable so the implementation of RPA does not mean employees have to be laid off. The last category *Availability & Flexibility* applies to processes that need to be performed right after a certain trigger. In that case, a bot can always act immediately while a human employee might wait for a while or is not working at the time the trigger occurs.

The next step in the framework is to make a process model with the use of BPMN. This notation has been used to capture business processes across various industries. Because modeling appears to be time consuming and not necessary to assess RPA suitability, the step is optional. On the other hand, it has some benefits when used in combination with the other steps, which include enhancing the understanding of the process, identifying inefficient processes, and already having the process steps for the RPA bot.

After the process modeling, it is evaluated if the process meets the mandatory criteria. To proceed to the next step, all criteria need to be met by the process. These criteria consist of:

- *Digital and structured data:* Assuming the RPA engine does not have advanced features to interpret data, the data should be structured. Otherwise human assistance might be needed, while human intervention should be minimal.

- *Few exceptions:* When multiple exceptions exist, the performance of the bot can be reduced and the implementation will be more expensive as additional programming is needed. Therefore, exceptions should be minimal.
- *Repetitive:* Processes should be recurring, otherwise there is no need for automation.
- *Rules based:* Preferably, the decision points in the process are minimal and the decisions occurring should be able to be solved with simple rules.
- *Stable process and environment:* No upcoming changes should be planned and the process should not be prone to change.
- *Easy data access:* There should be easy and well established ways to access all the process data.

If a process does not meet all the criteria yet, but it can be accomplished by re-engineering the process then this might be an option as well as long as it does not take too many resources. For the criteria, no values have been given when they are met or not. This means they are assessed by the subjective opinion of the user.

The last step in the framework is checking if the process meets the optional criteria. The first three criteria are areas where good RPA candidates can be found, whereas the last criterion is important in circumstances where it is not possible to dismiss people from their job. The optional criteria are:

- *Multiple systems:* RPA can switch between multiple systems just like a human and is therefore well suited for multiple systems.
- *Digital trigger:* With a digital trigger, even less human interaction is needed.
- Standardized process: Having a standardized way of executing a process makes it easier to program the steps for the RPA bot.
- Redeployable personnel: Employees executing the process need to be able to do other tasks, otherwise the benefits of the project might fall into insignificance.

Benefits and Shortcomings

Although the use of business process mapping is seen as an effective addition when identifying suitable processes for RPA [48], it is also time consuming. The reason for this is because a BPMN model is useful when trying to understand a process but it failed to cover several aspects when assessing RPA suitability. This includes data quality and data sources. Besides that, it is also too time consuming with the detail level chosen in the framework. Therefore, the modeling step is not scalable when assessing multiple processes. The authors give two suggestions to handle this. The first one is to leave the step away, while the benefits of having a process model are clearly described, meaning this is not the desired option. Therefore, the framework can benefit from a less time consuming way of creating a process model. The other suggestion is to put the step with the mandatory criteria before the modeling step, which results in fewer processes that need to be modeled.

Criteria for Method

Regarding the criteria stated in Section 1.2, the RPA Suitability Framework meets only one of the three criteria. It provides a clear structure of how to identify RPA candidates, so it is a systematic method. It performs a qualitative analysis in different steps of the framework, but the criteria to do both qualitative and quantitative at the same time is not met, although an attempt has been made to do so with the use of BPMN. Therefore, the method could be improved by introducing quantitative analysis as well in the sense of adding Key Performance Indexes (KPIs) to the business value step. On the other hand, this would be difficult as these KPIs could be process specific and obstruct the generalizability of the framework. The last criterion, including both high- and low-level, is also not met, as the method is only assessing the high-level side.

4.3 Method 2: Framework Using Process Mining for Discovering RPA Opportunities

Introduction Method

The framework developed by [29] provides a way to use process mining techniques to find and prioritize processes suitable for RPA. The addition of process mining techniques is chosen as it increases process understanding, checks the process quality, evaluates the impact of the implementation and can be used to discover new RPA opportunities.

Explanation Method

The framework consists of eight steps, including several indicators to identify if a process step has potential value to be automated. With these values, the process steps can be prioritized to find out what to focus on first. The first steps focus on eliminating threats and limitations because if these can not be reduced the identification should not be continued. This implies that the framework works as a funnel, the same as the RPA Suitability Framework does [5]. In step one, the threats process maturity and concept drift are addressed and in step two there is a check if the process is suitable for automation. This second step is done by loading the data set into the process mining tool and determining if there are no significant problems in the process that will not be solved by RPA implementation. In the third step, the non-RPA activities are discarded and in the fourth step the infrequent activities are removed, if there are any. These two steps help in reducing the number of tasks to inspect with process mining techniques. In the fifth step, several metrics are calculated for the processes with the help of process mining techniques. All the metrics are translated into a measurable indicator, resulting in quantitative criteria with which the worth of an automation project can be determined. These metrics, including their general calculation and process mining calculation, are:

- **Human error prone:** Eliminating human errors does not only improve the performance, it adds value to the process where human errors are made as well. To calculate this, the Human Error Indicator is used.

  Human Error Indicator = number of times activity is executed / number of cases activity is carried out for

  Process mining calculation: *Mean repetitions = absolute frequency / case frequency & Error rate = cases with repetition / total cases*

- **High frequency:** The value of a RPA implementation increases when applied to tasks that are executed often instead of tasks that happen once a year. The absolute frequency is calculated with the Frequency Indicator.

  Frequency Indicator = Number of times activity is executed / Dataset time range in years

  Process mining calculation: *Frequency = Absolute frequency/ dataset time range in years*

- **Time sensitive:** Because a RPA bot can work 24/7 without breaks, it carries out an activity much faster than a human. To calculate the time reduction that can be achieved with a RPA implementation, the time reduction indicator is used.

  *Time Reduction Indicator = 0.75*average execution time + average waiting time*

  Process mining calculation: *Time Reduction = (0.75*median activity time) + weighted average of median 3 most frequent queuing times*

- **Human productivity:** Employees do not longer have to carry out the tasks automated with RPA. Therefore, they can work on more meaningful tasks that make better use of their human capital. The amount of human work saved can be expressed in terms of Full Time Employee (FTE). One FTE equals the amount of time a full time employee works during the year. This is calculated with the use of the FTE's Saved Indicator.

  *FTE's Saved Indicator = (0.95*Total activity execution time) / (1656 * Dataset time range in years)*

Process mining calculation: *FTE's Saved Indicator = (0.95*Total activity execution time) / (Dataset time range in years)*

- **Cost reduction:** The costs of executing a task are reduced by decreasing waste, increasing compliance and the most important one: decreased employee costs. This is calculated as follows:

  *Reduced costs = FTE's saved*cost of FTE*

  Process mining calculation: *FTE's Saved Indicator = (0.95*Total activity execution time) / (Dataset time range in years)*

- **Irregular labor:** When a task happens irregular, it can be cost intensive for a company to hire new employees or pull current employees away from their other tasks. With a RPA bot, this is not a problem as the RPA script can easily be recreated. The amount of irregular work is calculated with the sudden fluctuation number.

  Sudden fluctuation indicator = (number of times activity is executed period x) / (number of times activity is executed period x-1)

  Process mining calculation: *visual inspection of the active cases over time*

The last metric can only once be evaluated for the entire process, not for individual activities. In the sixth step, the process activities are listed in order of highest added value, based on the discovered metrics from step five. In the next step, each activity is investigated on its technical suitability regarding RPA. This includes evaluating them based on the following process indicators:

- *Rule based:* To copy the execution of a process, the RPA bot needs to know which steps need to be executed in which order. These decisions are based on parameters and rules, defined by the programmer. If it is hard to define and program these decisions, the complexity of the project is increased and the technical suitability decreased.

- *Low variations:* A process with a high number of variations needs more time to be programmed and is more difficult to maintain because an update to a system means having to update each activity variation.

- *Structured readable input:* The RPA robot needs a structured and digital input to execute the activity steps on. The easier the input, the less dependencies the bot has and the less time is needed to program the RPA robot.

- Mature: Tasks that are expected to change in the near future, or are changing at the moment, are less appropriated for RPA. This concerns the maturity of these tasks.

This step is executed by interviewing a process expert. The last step gives an overview with information based on which a decision can be made about which activities to automate using RPA and in which order. This may result in that there are no suitable activities, or all activities are suitable.

Benefits and Shortcomings

After comparing the framework with a traditional approach, several expected benefits were confirmed. Based on expert validation, it turned out the added value of the framework was high. Especially, the process quality, that includes the assessment of process maturity, was highly appreciated by the experts. The main value adding part of the framework is process discovery. Generally in RPA projects, benefits and risks are estimated and considered unreliable. With this framework, both the benefits and some risks are given with a reliable and data-based estimate. This is unique of this framework compared to the others, because the other framework did not make their criteria quantifiable. Therefore, the approach for the criteria used in this framework is good to keep in mind when applying the criteria for the proposed framework.

On the other hand, several limitations exist for the framework. Although the framework is said to give the advantage of providing a strong basis for a business case for RPA, no business metrics were taken into account. Besides that, it fails to discover the data quality of the process steps. The authors also state that implementing process mining techniques solely to find RPA opportunities is not expected to be worth it, as it is a costly change. Therefore, they state that if it is already known that there is a high-level of automation, a more traditional approach can be more cost-effective than using process mining techniques. This shows another limitation of the framework, as it does not check on these criteria before using process mining techniques. This research could tackle that problem by first assessing whether it is worth applying process mining or not, resulting in a time-saving framework.

Criteria for Method

Regarding the set criteria for the method analysis, the framework does not conduct a thorough qualitative analysis to reap all the benefits from the quantitative analysis. When looking at ways to improve the method, the qualitative analysis could be extended by giving qualitative indicators for the business side as well. As both qualitative and quantitative analysis are included in the framework, this criterion is met. As the framework offers a clear structure consisting of several steps, it can be called systematical. Because the framework is identifying the opportunities within processes to automate with RPA, it is working on the low-level.

4.4 Method 3: Candidate Digital Tasks Selection Methodology for Automation with RPA

Introduction Method

The method proposed by [16] selects candidate tasks for RPA based on user interface (UI) logs and process mining techniques. To find out which tasks in an organization are the best to automate with RPA, they make use of Robotic

Process Mining (RPM), a class of tools discussed in Section 2.3. The goal of RPM is related to that of this method; the discovery of candidate tasks in user processes that can be automated with RPA.

Explanation Method

Figure 4.2 shows the different steps in the method. The method explains what information the UI log should contain to be able to derive tasks, how the UI log should be altered to be used by process mining techniques, how tasks can be discovered and how these candidate tasks can be selected for automation from the discovered tasks.

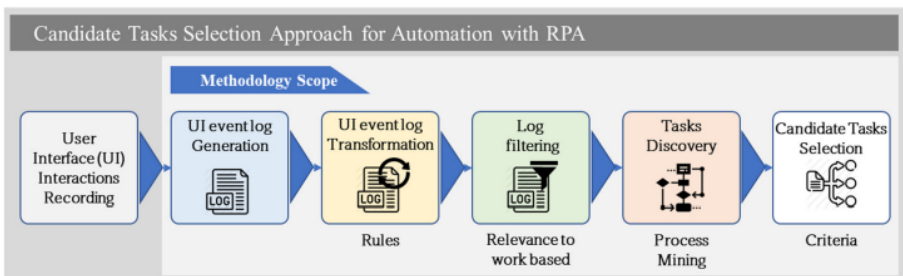


Figure 4.2: The approach to select candidate tasks for RPA [16].

The method begins with recording the performed tasks, when executed by employees while they are interacting with the user interface. From this recording, a UI log is generated. This log contains interactions between a user and software applications. With this UI log, four steps are executed within the method: *UI log generation, UI log transformation into a log supported by process mining techniques, routines discovery with process mining, and candidate tasks selection based on specific criteria.*

The first step is the *UI Event Log Generation.* Normally, the input of process mining techniques is an event log, but for RPM, which is used in this method, it is a UI log. A UI log represents a sequence of actions performed in chronological order by a user while interacting with several applications. After this, the next step is the *UI Log Transformation.* The UI log is transformed into a log ready for process mining techniques. The next step is *Relevance to Work-Based Filtering.* In this step, irrelevant actions to work are filtered out. Irrelevant actions consist of tasks that are not related to work tasks, such as visiting other websites or checking private email accounts. The next step is *Tasks Discovery* from the transformed UI log. This step identifies how tasks belonging to a business process are following each other based on the UI log. As a result, a process model is generated, showing the full behavior and giving a better understanding of the process behavior. The last step is the *Candidate Tasks Selection.* Based on the discovered process model, a selection of the relevant and candidate cases needs to be made. Based on the selection, a decision can be made which ones are relevant for automation. This selection is made with the help of three criteria:

- *Frequency:* The aim is to automate repetitive routines with RPA. To find this frequent occurring tasks, the process models are enriched with frequency. This is done by applying the case frequency technique.
- *Periodicity:* With this criteria, the periodic cases are identified, which are cases performed frequently but periodically.
- *Duration:* By automating tasks that take hours by an employee, a lot of time savings can be achieved. The duration of a task is calculated with the help of the duration of all tasks referring to the corresponding task and the mean duration of these tasks.

Benefits and Shortcomings

The challenges that arise with this method mainly have to do with the creation of the UI log. The first challenge is to identify how to transform the recording of a UI interaction based on mouse clicks into a UI log that can be used by process mining techniques. The second challenge is how to define an appropriate case ID of a UI log. The third challenge is how to calculate the duration of tasks when taking real-life situations into account. Because this research will not make use of RPM techniques, no need exists to create UI logs. These challenges will therefore not be discussed or resolved.

Criteria for Method

Besides these challenges, the method lacks in using qualitative criteria when selecting candidate tasks for RPA. The tasks are only chosen based on the UI event log, meaning this is purely quantitative. Therefore, regarding the criteria from Section 1.2, the method does not meet the criterion of performing both qualitative and quantitative analysis. In addition, a clear structure is used for the method, with well-described steps. This means the method meets the criterion of being systematic. As for the level criterion, the method is only operating on the low-level.

4.5 Method 4: Framework for Process Suitability Assessment (FPSA)

Introduction Method

As a solution to the lack of guidance on how to use process mining as data-driven approach to asses RPA process suitability, [49] proposed a framework for process suitability assessment (FPSA). The goal of the framework is to provide organizations a guide to asses RPA suitability in a standard and data-driven way. In this framework, the objectives of the organizations are taken into account, which means that the outcome of the framework differs from organization to organization based on the set objectives. For this framework, a data-driven analysis has been chosen, with only quantitative criteria. The reason for this is that the manual analysis can lead to several problems and errors and consumes a lot of time and effort as well. This data-driven framework is set up with the help of process mining frameworks, as process mining can act as a data-driven and fact-based solution to support different stages of RPA implementations. With the FPSA, the authors responded to the lack of methods that use process mining in the initial assessment of process suitability for RPA, before the specific process to automate with RPA are selected.

Explanation Method

In Figure 4.3, the FPSA method is showed. It starts on the left side with one or more candidate processes. In the next step, process data is extracted from the information systems that support the process execution. With this data, an event log is created that can be used with any process mining tool. After that, the event log is cleaned and transformed in a high-quality log in the pre-processing phase. The next phase is about using process mining techniques, to be precise a process discovery algorithm. Which algorithm this is, depends on the objectives and desired outcome of the organization. This is an important step because the process mining techniques can analyze the information from the event log that is needed to assess the suitability on. In the fourth step, this process information is analyzed in the categories performance, time and resource to generate the values of each process suitability criterion. In the last step, a scoring model will be filled with the values of the process criteria and the organizational objectives. With this model, a final score is calculated to reach a decision whether the process is suitable for RPA or not.

In the FPSA, eleven criteria are used. This number is based on literature research of 42 articles and reports and nine expert interviews. Out of the literature research, 36 criteria to assess RPA suitability were extracted and the expert interviews delivered twenty criteria. If a criterion existed in both sources, literature and expert opinion, it was seen as a indicator of the validity of the criterion. The twenty criteria mentioned by the experts all existed in the literature as well. After that further analysis of these criteria was done. Some of the criteria were not mandatory, meaning RPA can be performed without fulfilling such a criterion. Other criteria could not be measured such as the value of the process. Therefore, the analysis of the twenty criteria was done with the following points: 1) Whether the criterion can be measured or its value can be obtained. 2) Whether the criterion can be measured or assessed using process mining or not.

Both points relate to the fact that the authors want the FPSA to be completely data-driven. With this analysis, eleven criteria remained in the framework. These criteria are split over three categories. Table 4.2 shows the criteria, their category and the definition. All criteria are mandatory, except for the Structured Digital Data criterion. If the process input or output is not digital or structured, RPA is not possible at all. This can be seen as well in the Scoring

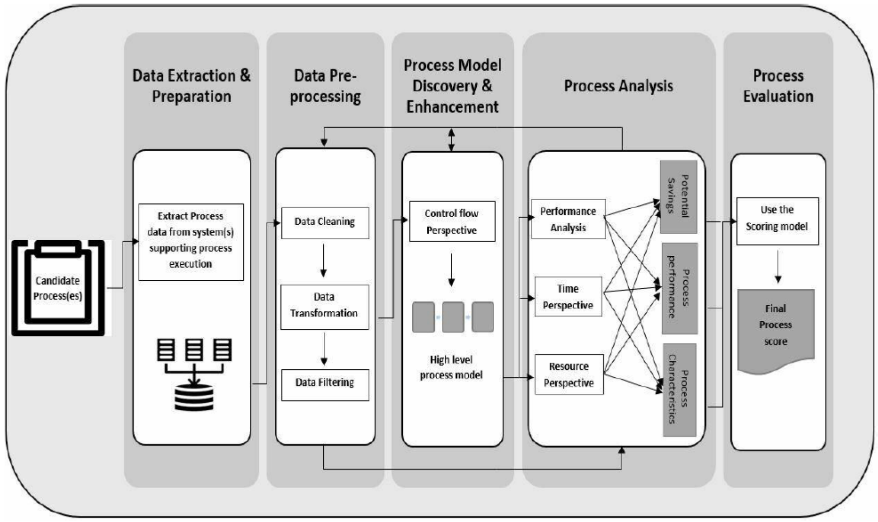


Figure 4.3: The Framework for Process Suitability Assesment (FPSA) [49].

Model of the FPSA, which is showed in Figure 4.4.

In the scoring model, the organization can fill in per criteria the value, the weight and the total score. The value is the result for the criteria from the process mining analysis. The weight depends on the organization's values. The total score consists of either 0 or 1. The zero stands for not achieving the criterion, assessed by the organization, and one means the criterion is achieved. Because it can differ from situation to situation and from organization to organization when a criterion is achieved, it is not possible to have a standard value for each criterion that fits all cases. The 100% weight is divided over all the ten not completely mandatory criteria. To calculate the final score, the weighted average formula will be used where for each criterion, the weight will be multiplied by the score and summing all of this for the ten criteria. After that, the final score can be evaluated using the scale presented in Table 4.3. This scale for assessment was developed by looking at the assessment conducted by major RPA vendors as well as literature research, meaning it is based on both academic sources and best practices.

Benefits and Shortcomings

As the FPSA is quite related to the desired output of the research conducted in this thesis, it is of great importance to look carefully at the differences between the two researches. This includes looking at the limitations of the FPSA, if they can be improved in this research and other ways in which the FPSA can be improved. A first limitation of the FPSA is that it is only demonstrated with sample data. The authors assessed the RPA suitability of a Purchase to Pay (P2P) process using a open-source event log. It was known that this process

Table 4.2: Overview of the criteria used in the FPSA [49].

Criterion	Category	Definition
Low Process Complexity	Process Characteristics	The number of process activities.
High Standardization Level	Process Characteristics	The total number of selected variances.
Rule-Based	Process Characteristics	Process rules are known or can be extracted.
Structured Digital Data	Process Characteristics	Standard, digital text.
Repetitive/Routine	Process Performance	The stable number of executions over time and no large time interval (not seasonal).
High Volume/Frequency	Process Performance	Total occurrences
Low Automation Rate	Process Performance	The percentage of events performed by system actors.
Low Exception Handling	Process Performance	Percentage of cases neglected out of the total executions.
High Number of FTE's	Potential Savings	Number of human actors working on the process.
High Execution Time	Potential Savings	The average handling time.
Prone to Human Error	Potential Savings	The rework rate.

was suitable for RPA. The outcome of the demonstration was a score of 70%, which means the process is suitable for RPA equivalent to what was known. The inability to evaluate the framework in a real context using a case study harms the evaluation results and would be an improvement which this research can offer.

Besides this demonstration, the framework was evaluated using experts' opinions. This is done to take into account whether the set objectives are met or not. An evaluation with both a process mining and a RPA expert has been conducted. Both experts indicated that the framework provides all the guidance that is needed to asses RPA suitability with process mining. A limitation mentioned by the RPA expert was that not always the required data can be extracted from information systems for the assessment of RPA suitability. Although for the execution of process mining, it is needed that the required data is saved, in ITSM tools always certain amount of data available. If saved properly, this means that when focusing on ITSM tools, as in this research, this limitation does not apply in the same way it does for FPSA. The main difference between the FPSA and this research is that the FPSA is focusing on the RPA suitability of processes, while this research is focusing on the RPA suitability of tasks within processes. In the research, the difference in definition between process and task was not mentioned by the author.

	Assessment criteria	Definition	Process 1		
			Value	Weight	Score
Process Characteristics	Low Process Complexity	Number of Process Activities			
	High Standardization Level	Total Number of variants			
	Rule-based	Rules can be easily extracted	-		
	Structured Digital Data	Standard, digital text	-	-	
Process Behaviour	Repetitive/Routine	Stable number of executions over time & no large time interval	-		
	High Volume/Frequency	Total occurrences			
	Low Automation Rate	Percentage of events performed by system users			
	Low Exception Handling	Percentage of cases neglected out of the total executions			
Potential Savings	High Number of FTEs	Number of Human actors			
	High Execution Time	Average handling time			
	Prone to Human Error	Rework rate			
		Total	-	100%	
		Weighted Score			

Figure 4.4: The Scoring Model, which is part of the last step of the FPSA [49].

Table 4.3: The Scoring Model Scale of the FPSA [49].

Final Score	**Assessment**
70% ≥	Highly Suitable
50% - 70%	Moderate Suitability
20% - 50%	Low Suitability
≤ 20%	Not Suitable

The goal of the FPSA is to be only data-driven so focusing on quantitative criteria, while this research takes both qualitative and quantitative criteria into account. But in reality, the FPSA is not completely quantitative. Three criteria in the Scoring Model, showed in Figure 4.4, can not be measured with a value. Their score depends on the subjective evaluation of the organization. These criteria are *Rule-Based*, *Structured Digital Data* and *Repetitive/Routine*. Although the idea of the FPSA to make a completely quantitative method to make sure a scoring model can be filled in is interesting, this shows that both qualitative and quantitative criteria are needed to asses RPA suitability, both for processes and tasks. To improve this model and still keep the scoring model, the qualitative criteria could be taken out of the scoring model and can be assessed before using the scoring model. In that way, only the quantitative criteria remain in the scoring model, making that part completely data-driven.

Another limitation of the research is that the organization decides for themself whether the value of the criteria in the scoring model is enough for a one or zero. They can determine that based on their own objectives. On the one hand, this is something the FPSA offers new to the scientific community, on the other hand, it goes against their idea of developing a data-driven, objective framework. The recommendation of the authors is for future research to look further into the elimination or reduction of the error percentage of this approach.

Criteria for Method

When looking at the criteria set in Section 1.2, the method makes use of a systematic approach with different categories and steps and uses quantitative metrics. Although the idea of the FPSA is to use only countable metrics, some metrics included are qualitative and therefore it could be said that also the qualitative criterion is met. Because this was not intended by the authors, it will also not be counted as met, leaving room for improvement in this research to combine both qualitative and quantitative metrics. Because the method is assessing the suitability of processes, the method is operating on a high-level.

4.6 Criteria Overview

This section analyzes all the criteria from the four methods that were discussed in this chapter. First, an overview is made of all the criteria, after which the ones that can be reused are extracted based on different selection points. The section ends with an overview of the criteria that will be used in the proposed framework.

4.6.1 Analyze Criteria for RPA Suitability Assessment

In the proposed framework, different criteria are used for the extraction of the criteria in the literature review. This literature review is described in Section 4. The investigated methods propose their used criteria in different ways. [5, 16] introduce the different criteria when proposing the framework, while [29, 49] discuss the criteria and the establishment of these beforehand. Also, the way in which the criteria are established differs per method. While [29, 16] give no explanation on how the set of criteria was build, [5] conducted a systematic literature review. [49] did this as well, but also held expert interviews to ensure the artifact is based on both literature and practice.

Table 4.4 shows an overview of all the 27 unique criteria used by the four methods. In the overview in Table 4.4, criteria that have a similar meaning but a different name are merged into one criterion. An example of this is the criterion *Structured Digital Data* from the overview. This criterion is a combination of the criterion *Digital and structured data* from method one, *Structured Readable Input* from method two, and *Structured Digital Data* from method 4. The complete list of 34 criteria that appear in the four analyzed methods can be found in Appendix D.

The overview shows extra information on the criteria in which method they occur and three other characteristics. The first characteristic is whether the criterion is mandatory or not. A mandatory criterion means that RPA cannot be implemented without this criterion being met. The second characteristic is whether the criterion applies to the process (P) or task (T) LoD, where the process matches the high LoD and the task the low LoD. The third characteristic tells to which type of analysis the criterion belongs: qualitative or quantitative. These characteristics help in the next section to extract the necessary criteria from the overview to use in the different steps of the framework. This is done by analyzing the differences between the characteristics of the criteria. As can be seen, some criteria still have a related name. If this is the case, the criteria differ in the sense of their other characteristics. An example is the criterion *Frequency*, which occurs two times in the table. The first time relates to the frequency of processes, and the second time to the frequency of tasks.

Some criteria have a value in their name, like *high*, *low* or *few*. When this appears in a quantitative criterion, it is not desirable to keep this. These criteria will be calculated and will receive a value. The values of different processes or tasks are compared, therefore no need exists to have a value in the name.

4.6.2 Extract the Final List of Criteria

After the creation of the criteria overview, as can be seen in Table 4.4, further analysis of these criteria was done to extract the final list of criteria for the proposed framework.

The proposed framework exists of two process parts and one task part, as can be seen in the initial sketch that is made of the proposed framework, which is shown in Appendix E. Therefore, different selection points are set up for the criteria of those three parts to select the criteria from the overview. For the selection of the criteria in the *first process part*, the following selection points are used: 1. The criterion should be applicable to processes. 2. The criterion should be mandatory. 3. The criterion should be qualitative, meaning no calculations are needed.

For the selection of the criteria in the second process part, the following selection points are used. 1. The criterion should be applicable to processes. 2. The criterion should be able to be measured with the use of process mining techniques. 3. The criterion should be quantitative.

For the selection of the criteria for the task part, the next selection points are used: 1. The criterion should be applicable to tasks. 2. The criterion should be able to be measured with the use of process mining techniques. 3. The criterion should be quantitative.

The summary of the selection points can be found in Table 4.5. The colors of the different parts match with the colors in Table 4.6. This table makes it clear which criteria could be used for which part of the proposed framework.

a8 -¿ 1 a21 -¿ 2 a22 -¿ 3 a3 -¿ 4

With the help of this analysis, nineteen criteria are selected to use in the framework, as can be seen in Table 4.8. This amount is divided into six criteria for the first process part, seven criteria for the second process part, and six criteria for the task part. Of these nineteen criteria, four criteria are newly introduced and fifteen criteria are reused from the four researched methods. The three new criteria are *Activity Frequency* for parts two and three, *Length* for part two and *Automation Rate* for part three. The first new criterion was added after this metric was found when exploring Celonis. The *Length* criterion calculates the same as *Complexity* in Table 4.6, but the length of a process does not only influence the complexity. Therefore, the decision has been made to change this name. The criterion *Automation Rate* appeared in Table 4.6 only for processes, but can be used for tasks as well and is therefore added.

Table 4.4: Overview of the 27 unique criteria from the four analyzed methods.

Criteria	**Method**	**Mandatory**	**LoD**	**Type of Analysis**
Structured Digital Data	1,2,4	Yes	P	Qualitative
Standardized process	1	No	P	Qualitative
Few exceptions / Low variations	1,2	Yes	P	Qualitative
High Standardization level	4	No	P	Quantitative
Low exception handling	4	No	P	Quantitative
Repetitive	1,4	Yes	P	Qualitative
Rules Based	1,2,4	Yes	P	Qualitative
Mature	1,2	Yes	P	Qualitative
Easy data access	1	Yes	P	Qualitative
Multiple systems	1	No	P	Qualitative
Digital trigger	1	No	P	Qualitative
Redeployable personnel	1	No	P	Qualitative
Frequency	2,3	No	T	Quantitative
Frequency	4	No	P	Quantitative
Time sensititve	2	No	T	Quantitative
Human Productivity	2	No	T	Quantitative
Cost reduction	2	No	T	Quantitative
Irregular labor	2	No	T	Quantitative
Periodicity	2	No	T	Quantitative
Low Process complexity	4	No	P	Quantitative
Low automation rate	4	No	P	Quantitative
High number of FTE's	4	No	P	Quantitative
Duration	3	No	T	Quantitative
High execution time	4	No	P	Quantitative
Prone to human error	4	No	P	Quantitative
Human error prone	2	No	T	Quantitative

Table 4.5: Selection points for the three steps in the proposed framework for which criteria have to be selected.

Part	P/T	Mandatory	Qual/Quant	Process Mining?
Step 3	P	Yes	Qual	No
Step 6	P	No	Quan	Yes
Step 7	T	No	Quan	Yes

Table 4.6: Analysis of the criteria from the methods, split into different parts that are explained in Table 4.5

Criteria	Method	Mandatory	LoD	Quan/Qual
Structured Digital Data	1,2,4	Yes	P	Qual
Standardized process	1	No	P	Qual
Few exceptions / Low variations	1,2	Yes	P	Qual
Standardization level	4	No	P	Quan
Exception handling	4	No	P	Quan
Repetitive	1,4	Yes	P	Qual
Rules Based	1,2,4	Yes	P	Qual
Mature	1,2	Yes	P	Qual
Easy data access	1	Yes	P	Qual
Multiple systems	1	No	P	Qual
Digital trigger	1	No	P	Qual
Redeployable personnel	1	No	P	Qual
Frequency	2,3	No	T	Quant
Frequency	4	No	P	Quant
Time sensititve	2	No	T	Quant
Human Productivity	2	No	T	Quant
Cost reduction	2	No	T	Quant
Irregular labor	2	No	T	Quant
Periodicity	2	No	T	Quant
Process complexity	4	No	P	Quant
Automation rate	4	No	P	Quant
High number of FTE's	4	No	P	Quant
Duration	3	No	T	Quant
Execution time	4	No	P	Quant
Prone to human error	4	No	P	Quant
Human error prone	2	No	T	Quant

Table 4.7: Overview of the 27 unique criteria from the existing four methods

Criterion	***Method***	***Mandatory***	***Process***	***Task***	***Qualitative***	***Quantit***
Structured Digital Data	1,2,3	✓	✓	X	✓	X
Standardized process	1	X	✓	X	✓	X
Few exceptions / Low variations	1,2	✓	✓	X	✓	X
High Standardization level	3	X	✓	X	X	✓
Low exception handling	3	X	✓	X	X	✓
Repetitive	1,3	✓	✓	X	✓	X
Rules Based	1,2,3	✓	✓	X	✓	X
Mature	1,2	✓	✓	X	✓	X
Easy data access	1	✓	✓	X	✓	X
Multiple systems	1	X	✓	X	✓	X
Digital trigger	1	X	✓	X	✓	X
Redeployable personnel	1	X	✓	X	✓	X
Frequency	2,4	X	X	✓	X	✓
Frequency	3	X	✓	X	X	✓
Time sensitive	2	X	X	✓	X	✓
Human Productivity	2	X	X	✓	X	✓
Cost reduction	2	X	X	✓	X	✓
Irregular labor	2	X	X	✓	X	✓
Periodicity	2	X	X	✓	X	✓
Low Process complexity	3	X	✓	X	X	✓
Low automation rate	3	X	✓	X	X	✓
High number of FTE's	3	X	✓	X	X	✓
Duration	[**a3**]	X	X	✓	X	✓
High execution time	3	X	✓	X	X	✓
Prone to human error	3	X	✓	X	X	✓
Human error prone	2	X	X	✓	X	✓

Table 4.8: The final list of criteria as used in the PLOST Framework.

Part 1	**Part 2**	**Part 3**
Digital and Structured Input	Cycle Time	Activity Frequency
Easy Data Access	Case Frequency	Case Frequency
Few Variations	Activity Frequency	Duration
Repetitive	Standardization	Automation Rate
Clear Rules	Length	Human Error Prone
Mature	Automation Rate	Irregular Labor
	Human Error Prone	

Chapter 5

The PLOST Framework

During the design and development phase, a framework has been designed that meets all the criteria set in this research. The proposed framework builds upon some components of existing methods, as well as adds some new parts. This chapter explains and highlights the proposed framework. It starts with a concise overview of the framework, after which a detailed explanation of the different steps is given together with a motivation on why the step is made like this.

5.1 Overview of the PLOST Framework

The proposed framework is called the PLOST framework, which stands for Prioritized List Of Suitable Tasks. The framework can be found in Figure 5.1. It consists of eight steps, that are described in detail in Section 5.2. The steps and layout are based on the initial sketch that is made of the proposed framework, which is shown in Appendix E.

The framework starts with the first step in the left corner and ends with the eighth step in the right bottom. The steps need to be executed in chronological order. As can be seen in the legend, a difference exists between qualitative and quantitative steps. The first four steps are qualitative and the last four steps are quantitative. Another difference can be found in the LoD. The first six steps operate on the high-level, while the last two steps are performed on the low-level. The steps on the high-level work as a funnel. With the output of the steps, a decision can be made whether to keep the processes in the framework or to remove them. In this way, the quantitative analysis resulting from the process mining step is only applied to processes and tasks that are worth analyzing. The goal is to minimize the run time of the framework with this, as the process mining step is the most time-consuming one in the framework.

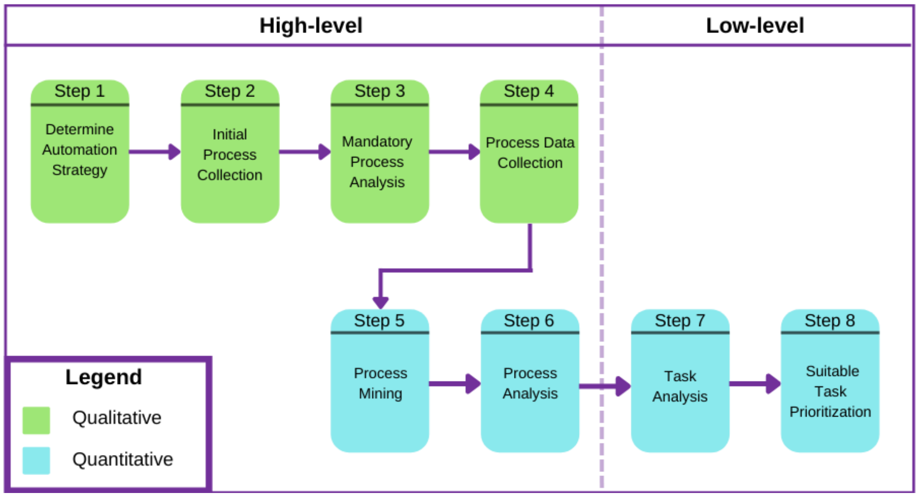


Figure 5.1: Overview of the PLOST Framework

5.2 Detailed Description of the PLOST Framework Elements

As seen in the previous section, the PLOST Framework consists of eight different steps that need to be performed in chronological order. This section explains each step, together with its usage and elements. This is assisted by the addition of an example use case. Then, a motivation is given why this step is added to the framework and why it is designed in a certain way. Finally, the desired output of the step is listed.

5.2.1 Step 1: Determine Automation Strategy

Explanation

To determine the strategy of the organization regarding the RPA implementation, the PLOST Framework starts with making up an organization's automation strategy. In this way, the output of the framework is customized to the wants and needs of the organization. The automation strategy consists of two parts: the prioritization of the business values and the determination of the risk level. These two parts are executed with the help of the stakeholders of the implementation. These stakeholders can be (process) managers, domain experts, process mining experts, and RPA experts.

The first thing to set up for the creation of the automation strategy is the business values prioritization. Different business values can be achieved by automating tasks but to decide which task to start automating with, it is important to know the prioritization of the business values.

Because multiple opinions have to be taken into account to make a decision regarding the automation strategy, a prioritization method can be used [15]. Different prioritization methods exist, among which Cumulative Voting (CV), described by [19]. CV is also known as the 100-Point Method or $100 test. Because of its simpleness and straightforwardness, it has been used in various prioritization researches in software engineering. Each stakeholder is given a constant amount of imaginary units, e.g. 100 points, that he or she can divide over the different issues. In this way, the amount of points assigned to an issue represents the stakeholder's preference in relation to the other issues, and therefore the prioritization. The points can be distributed in any way the stakeholder wants, meaning he or she is free to assign the whole amount to only one issue or divide it equally over all the issues.

For the business values prioritization, three values are used. Why these three are used in explained later in the Motivation part of this step. The three business values are:

- **Time Savings:** By automating processes that are performed often or take a lot of time, great value can be found in the time saved. Besides that, bottlenecks in the processes can be automated, which raises the total throughput time of the process.
- **Quality & Accuracy Improvement:** Where humans work, mistakes are made. When automating tasks, the error rate can be minimized resulting in less rework and rejections and removing delays because of these.
- **Availability & Flexibility Increase:** While human employees take breaks and work most of the time eight hours a day, RPA robots are available 24/7. This means a bot will always execute a task immediately if no human interference is needed. Besides that, when the demand for a certain task is higher, a RPA bot can simply be copied while a new employee has to be on board. This makes it easier to scale up and down when a task is automated.

With the assessment of the risk level, the organization indicates how much risk they are willing to take with the RPA implementation. When it is the first time an organization is implementing RPA, they might want to play it safe and take fewer risks, while when they already have some experience with RPA, they learned from their past implementations and dare to take more risks. The risk level does not say anything about the potential business value a process has when being automated. It is mainly about aligning the organization's automation strategy with the desired risk level. The outcome of this risk level assessment will be used in step seven of the framework, which will be discussed in Section 5.2.8

The risk levels are assessed based on two main factors: *Process Importance* and *Process Complexity*. The former determines whether or not essential processes are considered, and the latter determines which level of complexity the process can have. The framework includes three levels of risk, where the first one means the highest risk level and the last one the lowest. The levels can be found in Table 5.1. A high risk level is given to essential processes that are complex, while a low risk level means non essential processes with low complexity. Between these two is the medium risk level, which involves essential but not complex processes or non-essential but complex processes.

Table 5.1: The three different risk levels based on process importance and process complexity.

Risk Level	**Process Description**
High	**High** importance & **High** complexity
Medium	**High** importance & **Low** complexity OR **Low** importance & **High** complexity
Low	**Low** importance & **Low** complexity

Example

Figure 5.2 shows an example of the Business Values Prioritization model with the three discussed business values. It has been completed by two stakeholders, S1 and S2. As can be seen in the figure, the two stakeholders have different opinions about the business values because they divided their 100 points in different ways. These two opinions together form the total Business Values Prioritization, of which the outcome can be seen in the column *Total*. The order of the business values in the example of Figure 5.2 is: 1. Time Savings 2. Quality Accuracy Improvement 3. Availability Flexibility Increase. This outcome is used to prioritize the suitable tasks in the final step of the PLOST Framework.

Business value	**S1**	**S2**	**Total**
Time Savings	50	35	85
Quality & Accuracy Improvement	35	40	75
Availability & Flexibility Increase	15	25	40
Total	100	100	200

Figure 5.2: Business Values Prioritization model that uses Cumulative Voting

For the organization in our example, it is their first experience with RPA. Therefore, their desired outcome is to have a successful showcase, that convinces more teams within the organization to implement RPA in their work. To increase the chance of a successful outcome, they go for a low risk level.

The complete automation strategy can be found in Figure 5.3 and shows how the automation strategy looks like for the example use case. The scores of the business values are visible on the top part and the chosen risk level is shown in the bottom line.

Business value	Score
Time Savings	85
Quality & Accuracy Improvement	75
Improved Employee Satisfaction	40
Risk level	Low

Figure 5.3: Automation strategy of the example case.

Motivation

The desired outcome of a RPA implementation differs per organization. By customizing the task identification to the wants and needs of the organization, the chance of a successful implementation is increased. Therefore, I chose to start the PLOST Framework with creating a automation strategy. It is the first step so that the outcome of the two components can be used to make decisions throughout the framework. It consists of two components for a reason as well. The business value prioritization helps making clear to all stakeholders what the desired business value is. If there is no clear business value to be achieved by implementing RPA, the implementation will be a waste of time and money. The ranking of the business values will come back in the final step of the framework, where it assists to make the final prioritization of the tasks. The three used business values are inspired by the method created by [5]. While this method proposes four business values, the proposed framework will only use three and discards the value *Employee Satisfaction*. The reason for this is that employee satisfaction is not a value that can be measured through data gained from the ITSM system.

The risk assessment helps the organization to align the RPA project with their experience level. The three risk levels that are part of the assessment give the organization choice which risk level matches their goal but makes the decision not too broad by providing too many options. The three risk levels are inspired by the method by [5] as well. While that method starts with identifying the risk level in the first step and the business value in the second step, the framework in this research will combine these two components into the first step. This combination is made because they form together a good base on which a final decision what to automate can be made.

Output: Automation Strategy

By drawing up the outcomes of the business values prioritization and the risk level assessment, the organization's automation strategy has been determined.

5.2.2 Step 2: Initial Process Collection

Explanation

In this step, processes are collected at the organization. This is done with the use of interviews in a semi-structured way. The participants in the interviews are domain experts in the scope of the implementation. Such an expert can be any role or function that an employee within the scope can have, from manager to system administrator. An interview script for these interviews can be found in Appendix B. This script consists of three parts: an introduction, process and closing questions. For each topic or question, a motivation is given why it is important.

Example

In case of our example use case, three interviews were conducted with stakeholders. These interviews resulted in six processes. These processes form together the initial process selection and are used as input for the rest of the framework.

Motivation

After the creation of the automation strategy, it is important to have a starting point in the sense of an initial set of processes. This is achieved in this second step of the framework. Because the experts already thought about the automation strategy, they can be interviewed to gather the processes for the initial process selection as well. When not starting with such a selection but start with looking at the data, too much information is available which makes it hard to focus on the processes that could benefit from being automated. Still it is important to ensure that the right processes are selected, therefore the correct answers need to be asked. This is possible with the semi-structured set-up of the interviews explained in this second step. More information on the semi-structured interviews can be read in Section 3.2.2.

Output: Initial Process Selection

The output of this step is the initial process selection. This selection will be used for the next steps of the framework.

5.2.3 Step 3: Mandatory Process Analysis

Explanation

The third step takes as input the initial process selection from the previous step. Then these processes are assessed on the basis of six qualitative criteria. All these criteria are mandatory, meaning that a process should meet all of them. If that is not the case, the process will be removed from the selection. In this way, this step works like a funnel. This saves time later in the framework because the processes that do not meet the mandatory criteria are not considered when looking at the process data, which is the most time-consuming step in the framework. The analysis takes place on the high-level of the processes.

The six criteria that are involved in this step are:

1. *Digital and Structured Input:* The data input for the RPA robot needs to be structured and digital. The more readable the input is, the easier it will be to program the robot. If there is no structure at all, human help is needed to interpret the data, which should be avoided.

2. *Easy Data Access*: It should be easy to access the data needed in the process, to make the execution of the framework as fluent as possible.

3. *Few Variations:* A process with multiple variations needs more time to be programmed, can have reduced performance, and is more difficult to maintain. Therefore, the amount of variations should be minimal.

4. *Repetitive:* The process should be repeated in the same way over and over.

5. *Clear Rules:* The process exists of clear steps and decision points, which make it possible to define the process so they can be programmed by simple rules.

6. *Mature:* The process does already exist some time, does not have any upcoming changes in the near future, and is not prone to changes. If a process is not mature, the maintenance of the RPA robot will outweigh the benefits of the implementation.

Example

Figure 5.4 shows the Mandatory Process Analysis of the processes of our example use case. All the six processes from the initial process selection are assessed and only the first and fifth processes satisfy all the six mandatory criteria. This means that these two processes remain in the selection, while the other four are filtered away.

Criteria	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Digital and structured input	✓	✓	✓	X	✓	X
Easy data access	✓	X	✓	X	✓	X
Few variations	✓	✓	X	✓	✓	✓
Repetitive	✓	X	✓	✓	✓	✓
Rules Based	✓	✓	✓	✓	✓	✓
Mature	✓	✓	X	X	✓	X
Filtered away	X	✓	✓	✓	X	✓

Figure 5.4: Mandatory Process Analysis of the processes from the example use case.

Motivation

The decision to put a mandatory process analysis after the initial process are collected is made because later in the framework quantitative analysis will be conducted. Such a quantitative analysis is time-consuming as a large amount of process data needs to be gathered for this. To ensure only relevant processes are analyzed in the quantitative analysis, this qualitative check is executed. This is also why all the criteria in the step are mandatory. Together they form a strict pre-selection before the process data gathering takes place. A qualitative check can be done without having to gather data and can be based on process knowledge. This knowledge was gained during the previous step. The qualitative process analysis is based on six qualitative criteria. The collection and creation of this set of criteria is discussed in Section 4.6 and is based on the extensive literature research of the method by [5]. This method includes a mandatory process check as well but applies it after the process model is made. In their evaluation, it can be read that they would recommend to place a mandatory criteria check before the most time-consuming step in a framework. Therefore, the PLOST Framework implements this recommendation.

Output: Revised Process Selection

With the help of the filtering in this step, a revised process selection has been made. This selection consists only of processes that meet the mandatory criteria. For our example use case, the revised process selection consists of two processes.

5.2.4 Step 4: Process Data Collection

Explanation

In the fourth step, the process data is collected for the processes in the revised process selection from the previous step. This is done by searching for the data in the ITSM tool. Which tool this is, depends on the organization. Examples of ITSM software are Marval, ServiceNow, SolarWinds, Jira and BMC [1].

With the collected process data, an event log is created. This event log should be able to be imported into any process mining tool and in different formats.

Example

In our example use case, event data from the two processes is collected from the ITSM tool. With this event data, two event logs are made, one for each process.

Motivation

By collecting the data in the fourth step and not right after the initial process selection has been made, time is saved because data for less processes is collected.

[1] `https://www.gartner.com/reviews/market/it-service-management-tools`

By turning this collected data into event logs, process mining techniques can be applied as a next step.

Output: Process Event Logs

The output of this step is an event log for every process in the revised process selection.

5.2.5 Step 5: Process Mining

Explanation

With the event logs of the processes in the revised process selection, the next step is to apply process mining. The user of the framework can choose for themself which process mining tool is used for this step. Examples of process mining tools, that were also discussed in Section 2.2, are Celonis, Disco and ProM. After uploading the event data, visualizations of the processes can be made.

Example

For the example use case, the process mining tool Celonis is used. The visualizations of the processes can be found in Figure 5.5 and Figure 5.6. The first process, in Figure 5.5, is an order management process and the second process, in Figure 5.6 is an account payable process. Both figures do not show all the activities that can be part of the process but show the three most common variants of the processes.

Motivation

This step provides quantitative metrics by applying process mining techniques. Process mining is added to the framework to give objective evidence why certain processes and tasks can have more priority in being automated than others. The step is placed in this position so it can be executed right after the event logs are created in the previous step. This means this step could not be done earlier in the framework and there is also no reason to do it later. It is a logical follow-up on the data collection step.

Output: Visualization of Processes

The output of this step is the visualization of the processes in the revised process selection as process models. These models provide as well the statistics for the different processes and their tasks.

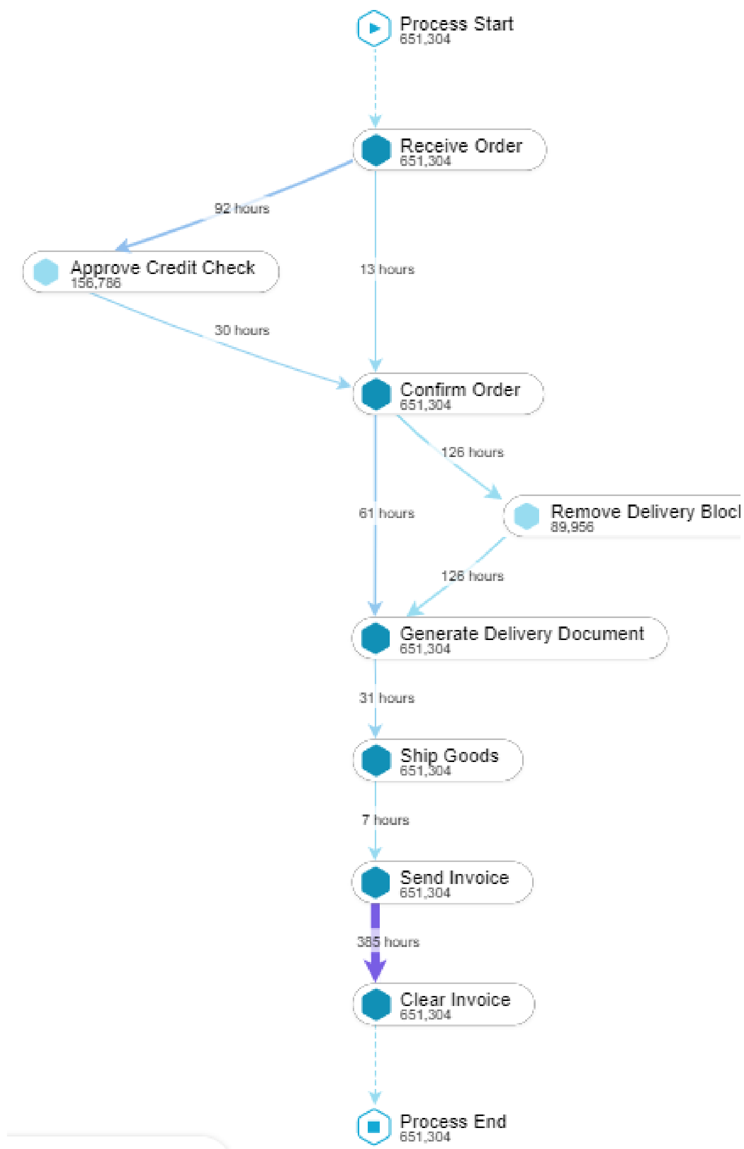


Figure 5.5: The visualization of the first example process in Celonis.

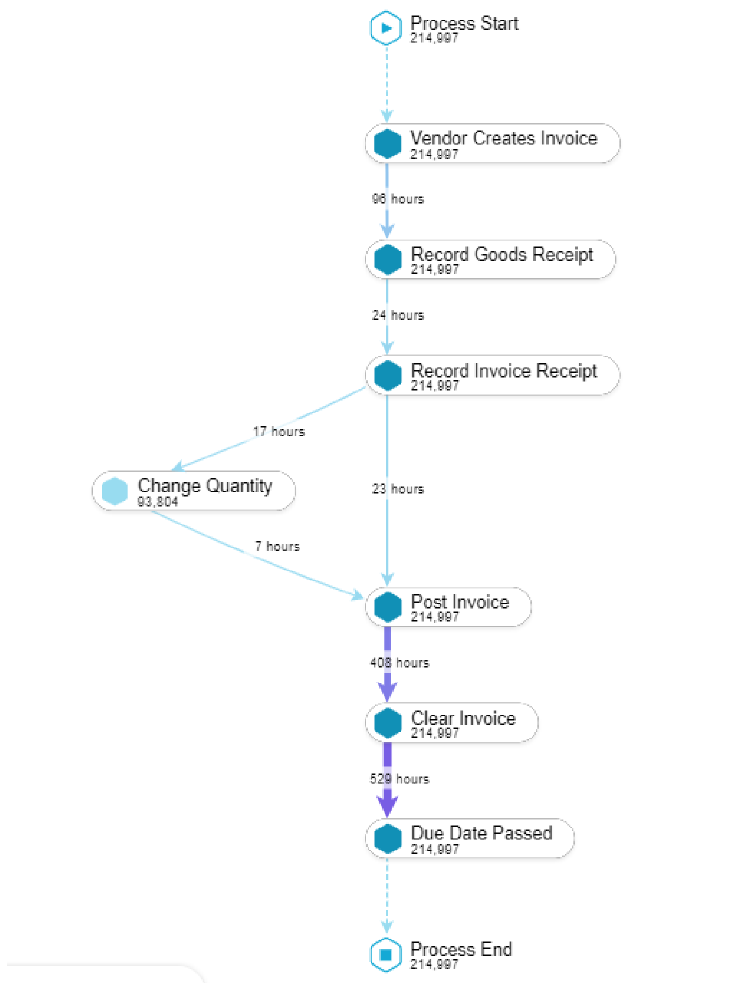


Figure 5.6: The visualization of the second example process in Celonis.

5.2.6 Step 6: Process Analysis

Explanation

In this step, the remaining processes from the revised process selection are assessed against different quantitative criteria. This happens at the high-level. It is done with the help of the output of the previous step, the visualizations of the processes together with their process statistics. This analysis helps choosing which process matches the best the chosen risk level from the first step.

The quantitative criteria that are used are:

1. *Cycle Time:* The cycle time of the process is the average handling time that is needed to go from the process start to the process end.

2. *Case Frequency:* The frequency is the total amount of occurrences in a specific time.

3. *Activity Frequency:* The activity frequency is the total amount of occurrences of all the different activities of a process.

4. *Standardization:* The standardization can be determined by looking at the total number of variants that the process has. A high standardization means a low number of variants.

5. *Length:* The length of the process is the average amount of tasks/events/activities that occur per process/case. The longer a process is, the more different tasks have to be automated to automate the complete process.

6. *Automation rate:* With the percentage of events performed by the system the automation rate is determined. A high automation rate means a high percentage of events performed by the system. A condition for this metric is that the performer is known.

7. *Human Error Prone:* The rework rate of the process tells how prone the process is for human employees to make mistakes. The rework rate is the number of activities that are executed more than once during the execution of a process.

Each of the six criteria contributes to the quantitative analysis of the processes. With this analysis, it becomes clear what the importance and the complexity of the processes exactly are. This overview can then be aligned with the determined automation strategy from step one. With this information, a decision can be made regarding the process, or processes, that remain in the framework.

Example

For our example use case, the quantitative process analysis is made based on the visualizations in the previous step and can be found in Table 5.2. The chosen

Table 5.2: Quantitative process analysis for the two processes of the example use case.

Criteria	**Process 1**	**Process 2**
Cycle Time	26 days	52 days
Case Frequency	988,101	604,472
Activity Frequency	7,707,187.8	5,621,589.6
Standardization	507 variants	14,072 variants
Length	7.8 tasks	9.3 tasks
Automation Rate	0.23	0.38
Human Error Prone	1.1	1.3

risk level is low, meaning the organization wants to implement a non-essential process with low complexity.

Whether a high- or low-value is better depends on the chosen risk level. For a low risk level, a low value of the criteria is better, while a high risk level prefers high values. The medium risk level is in the middle and for this risk level, it is best to choose both processes to keep in the framework.

When we look at Table 5.2 while having in mind that our example use case preferred a low risk level, we can assess which process matches the risk level better. For the criteria *Cycle Time*, a higher time means a higher complexity because more time is needed. This means our example organization could better choose the process with the lowest cycle time. This applies to the example organization for each criterion.

As can be seen in Table 5.2, the first process scores for four out of the six criteria the best regarding the values of the chosen risk level. Because the difference between the processes is that high, the second process is filtered away from the framework, while the first process goes to the next step.

For our example use case, the quantitative process analysis means that one process is filtered away and one remains. In other applications of the framework, it can be the case that all the processes from the revised process selection remain in the framework or a subset of the processes.

Motivation

The decision to add quantitative analysis to the framework is made because objective evidence for a prioritization is pursued. In this step, the analysis focuses on the high-level as the low-level is more detailed and therefore more time-consuming. By starting at the high-level, the processes can be matched with the chosen risk level, which will result in a higher chance of a successful RPA implementation. The seven criteria used in this step are chosen based on the criteria overview that was made in Section 4.6, as well as gaining inspiration during experimenting with process mining. This experimenting has lead to the addition of the criteria *Activity Frequency* and *Length*, because these two metrics seemed relevant to base the risk level on as well.

Output: Process(es) Aligned with Risk Level

The output of the quantitative process analysis is one or more processes that match the chosen risk level. Six quantitative criteria are used to come to this decision. This output will be used in the next step to perform a task analysis.

5.2.7 Step 7: Task Analysis

Explanation

In this step, the different tasks within the remaining process, or processes, are assessed with help of different quantitative criteria. This analysis takes place on the low-level. The criteria that are used in this step are task-specific criteria of which the value can be retrieved using the visualizations of the fifth step.

The different quantitative criteria in this step are:

1. *Activity Frequency:* The activity frequency is the total amount of executions for a specific task per time period.

2. *Case Frequency:* The case frequency is the number of unique cases in which this activity appears.

3. *Duration:* = The average duration of the total number of executions of the specific task. With this average handling time, the tasks that take a long time can be identified because what takes hours by a human employee can be performed by a RPA bot in milliseconds.

4. *Automation Rate:* = When a task is already fully automated, the addition of RPA has less impact on the execution. Therefore, the automation rate is also a metric in this step. It is calculated by the ratio between the absolute frequency of the task and the number of times the task is performed by a system. A condition for this metric is that the performer is known.

5. *Human Error Prone:* = Assessing the rework rate at the task level identifies the activities that are performed several times in a single case. The rework rate can also be called the activity repetition. Often this is the result of mistakes by human employees. Therefore, this metric tells how prone the task is to doing wrong. The rework rate is the ratio between the absolute frequency (af) of the activity and the number of cases (nc) where it appears. So $R = af/nc$.

6. *Irregular Labor:* = When a frequent task is executed irregularly, it is more suitable for RPA. The reason for this is because scaling up or down the workforce needed to execute a task is cost-intensive. Employees were focussing on other tasks and now also have to execute this task again.

The amount of irregular labor is measured with the sudden fluctuation indicator. Sudden fluctuation indicator = (number of times activity is executed in period x) / (number of times activity is executed in period x-1). The time period can be a day, week, month, or year depending on the specific task. A condition for this metric is that the process data is gathered over a longer time period than only period x. The desired value should be around 0. When it has a bigger value, it means the frequency of the activity is decreasing or increasing.

In the list of criteria are two different types of frequencies: the activity frequency and case frequency. [20] describe clearly the difference between an activity and a case. An activity is a well-defined step in a process and a case is a process instance. So the activity frequency is the number of events associated with an activity and the case frequency is the number of unique cases associated with an activity. With the difference between these two metrics, the rework rate can be calculated.

Example

Table 5.3 shows the task analysis of the different tasks in the last process of the example use case. The whole process contains 32 tasks but in the example of this step, we will use only the eight tasks from Figure 5.5 to keep it clear. Table 5.3 only shows task numbers but the corresponding task activities are: 1. Receive Order 2. Approve Credit Check. 3. Confirm Order 4. Remove Delivery Block 5. Generate Delivery Document 6. Ship Goods 7. Send Invoice 8. Clear Invoice.

Table 5.3: Quantitative task analysis for the tasks in the last process of the example use case. The duration is shown in hours.

Criteria	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Activity Frequency	651,304	223,564	651,304	89,956	651,304	651,304	798,530	651,304
Case Frequency	651,304	156,786	651,304	89,956	651,304	651,304	651,304	651,304
Duration	52,5	30	93,5	126	31	7	385	27
Automation rate	0.5	0	0	0	0.75	0	0	1
Human Error Prone	1	1,43	1	1	1	1	1,23	1
Irregular Labor	-0.05	0.34	-0.05	-0.05	-0.05	-0.05	-0.28	-0.05

Motivation

This quantitative analysis focuses on the low-level and it follows the previous step as that one focused on the high-level. The low-level analysis is applied later in the framework because the final ranking will also be based on this analysis. That is also the reason why two types of quantitative analysis are added to the framework: the first analysis is to filter on the right risk level, the second analysis is to provide metrics for the final ranking. This quantitative task analysis is based on the analysis executed in the methods by [30, 49]. Most of the six criteria used in this step are reused from those two analyses as well, as can be found in Section 4.6. This applies for the criteria *Case Frequency*, *Duration*, *Automation Rate*, *Human Error Prone*, and *Irregular Labor*. Because they give a good representation of the different characteristics of a task, they are used in this framework as well. Besides that, the criterion *Activity Frequency* is added to the analysis based on some experimenting with process mining tools. Another reason to add this set of criteria to the framework is that they can all be matched with at least one of the business values from the automation strategy. This will be further explained in the next step.

Output: Quantitative Task Scores/Values

The output of this step is an analysis of the tasks in the remaining process. Six different quantitative criteria are used to make this low-level analysis. It will serve as the basis for the final prioritization.

5.2.8 Step 8: Suitable Task Prioritization

Explanation

In the last step of this framework, the results from the previous steps form the final output: a prioritized list of tasks that are suitable to automate with RPA. Two things are needed to make this output: 1. The automation strategy from the first step. 2. The task analysis from the seventh step.

With these two components, the final prioritization can be made. The six analyzed criteria from the previous step all match one or more business values from the automation strategy. The overview in Figure 5.7 shows which criteria belong to which business value. This distribution helps to determine the ranking.

Criteria	Time Savings	Quality & Accuracy	Availability & Flexibility
Activity Frequency	✓	✓	✓
Case Frequency	✓	✓	✓
Duration	✓	X	X
Automation Rate	✓	✓	✓
Human Error Prone	X	✓	X
Irregular Labor	X	X	✓
Total	**4**	**4**	**4**

Figure 5.7: The overview of which criteria from the task analysis belongs to which business value from the automation strategy.

The ranking is based on the task analysis from the previous step in Section 5.2.7. Per criteria, it is analyzed which task scores the best and which task the worst. What is the best or worst differs per criteria. For the criteria activity frequency, case frequency, duration, and human error prone applies that the higher the value is the more suitable the task is for automation. For the automation rate it is the other way around, so the lower the value the higher the suitability. For the criterion irregular labor, the difference between the value and 0 has to be decided. The higher this difference is, the more suitable the task is to automate with RPA.

With the desired values in mind, the task analysis from Table 5.3 can be ranked. The best value per criteria is ranked with *N*. *N* is the number of tasks in the task analysis. The next best value is ranked with *N-1*, the second-best with *N-2* and so on. When two or more tasks have the same value, they will get the same ranking.

After the ranking has been made, the values from the three business values that were received during the first step are used. In this step, the automation strategy was determined which resulted in a prioritization of the business values and a risk level. The prioritization is used to make up the final list of prioritized tasks. To get this, the values of the ranking are multiplied by the values from the prioritization of the business values.

Example

Table 5.4: Task ranking for the tasks in the remaining process of our example use case.

Criteria	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Activity Frequency	7	6	7	5	7	7	8	7
Case Frequency	8	7	8	6	8	8	8	8
Duration	5	3	6	7	4	2	8	2
Automation rate	7	8	8	8	6	8	8	5
Human Error Prone	6	8	6	6	6	6	7	6
Irregular Labor	6	8	6	6	6	6	7	6

Table 5.4 shows the ranking of the tasks in our example use case. With help of the scores of the three business values in Figure 5.3, the final prioritization can be made up. The final prioritization can be found in Table 5.5. The scores in this table are assessed by multiplying the values from the task ranking with the values from the business values. When a criterion belongs to all three business values, the business value with the highest priority score is taken to calculate

the final score. To give an example: T1 was ranked with a 7 for the criterion activity frequency. Activity frequency belongs to all three business values. The highest value of the three business values is Time Savings with a score of 85. Then, 7 is multiplied by 85, which results in a score of 595.

Table 5.5: Task prioritization for the tasks in the remaining process of our example use case.

Criteria	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Activity Frequency	595	510	595	425	595	595	680	595
Case Frequency	680	595	680	510	680	680	680	680
Duration	425	255	510	595	340	170	680	170
Automation rate	595	680	680	680	510	680	680	425
Human Error Prone	450	600	450	450	450	450	525	450
Irregular Labor	240	320	240	240	240	240	280	240
Total	2985	2960	3155	2900	2815	2815	3525	2560

The last row in Table 5.5 shows the final prioritization of the tasks. As can be seen, Task seven has the highest score which means it is the most suitable task to automate with RPA, regarding the other tasks within this process.

Motivation

In this final step of the framework the prioritization of suitable tasks for RPA is made. This happens with help of the prioritization scores of the business values in the automation strategy, because in this way the output of the framework can be customized to the desires of the organization. Before the scores of the business values prioritization are multiplied, the ranking of the different criteria is made. This is done so it becomes clear for each criterion which task scores the best. I chose to do this with the scores N for the highest value, where N is the number of tasks, as leaving the values just as the values for the criteria will not provide a score that can be used for the prioritization. Another option that was researched was to give the highest value the score one and the lowest value the score N, so the other way around. Although this would have been more logical as society is normal to value something that is the highest with the value one, it was desirable for the prioritization to have a high score for the highest value. The reason for this is that this ranking is later used to multiply with the score of the business value.

For this final step, the Scoring Model used in the FPSA by [49] served as inspiration. Where users of the FPSA can choose in the scored model how many percentages they give to each criterion, the prioritization in the PLOST

Framework is based on the scores of the business values prioritization. Besides that, the Scoring model of the FPSA gives a score to a process which determines whether the process is suitable for RPA, while the proposed framework in this research filters the processes that are not suitable for RPA and gives as output a list of prioritized tasks that are all suitable for RPA. The similarity between the two is that both are a table in which values for different criteria can be filled in, which is then multiplied by a rating.

Output: Prioritized List Of Suitable Tasks

The output of this final step, and therefore the entire framework, is a prioritized list of tasks based on their suitability to be implemented with RPA.

5.3 Automate with the PLOST Framework

The PLOST Framework strongly focuses on the question what to automate with RPA within your organization. It does not focus on how to implement such an automation. Therefore, this section will introduce how to do this. It starts by motivating why the automation is not part of the framework and finishes with recommending two different ways of how the output of the PLOST Framework can be automated.

Motivation

When recurring to the RPA lifecycle, which is described in Section 2.1, the PLOST Framework focuses solely on the first stage in which the context is analyzed to determine which processes or tasks are candidates. The second stage in the lifecycle is to design the specifications of the robot. To be able to design such specifications, knowledge on RPA robots is needed. The different steps in the PLOST Framework can now all be executed by someone with little RPA experience, as the steps guide a user through all the actions that need to be executed. If steps about how to implement RPA would have been added, the usability of the framework would probably decrease as it would require specific RPA knowledge. The second objective was to provide the partner organization a framework to select the best suitable candidates to start doing RPA with. This objective assumes no prior RPA knowledge is available and therefore a framework that can be applied by something without this experience needed to be designed. The result is that the PLOST Framework focuses on what to automate with RPA and not on how this RPA implementation should be designed.

5.3.1 Recommendations on Automation with the PLOST Framework

In this section, two different recommendations are given which method or framework to follow when one wants to implement the output of the PLOST Framework.

The framework by [31] offers variable stages for the RPA lifecycle, so that it offers guidelines with enough flexibility that it can be applied in complex corporate environments. The framework is divided over three phases: initialization, implementation, and scaling. These three phases contain nine project-based stages. Some of the stages are executed once per RPA project, others are repeated continuously. The complete framework can be found in Figure 5.8. After following the PLOST Framework, one can continue with the Screening step from the framework by [31]. The steps *Identification* and *Alignment* can be skipped, as in these steps respectively the candidate to automate is identified and aligned with the business strategy. These two actions are already executed in the PLOST Framework.

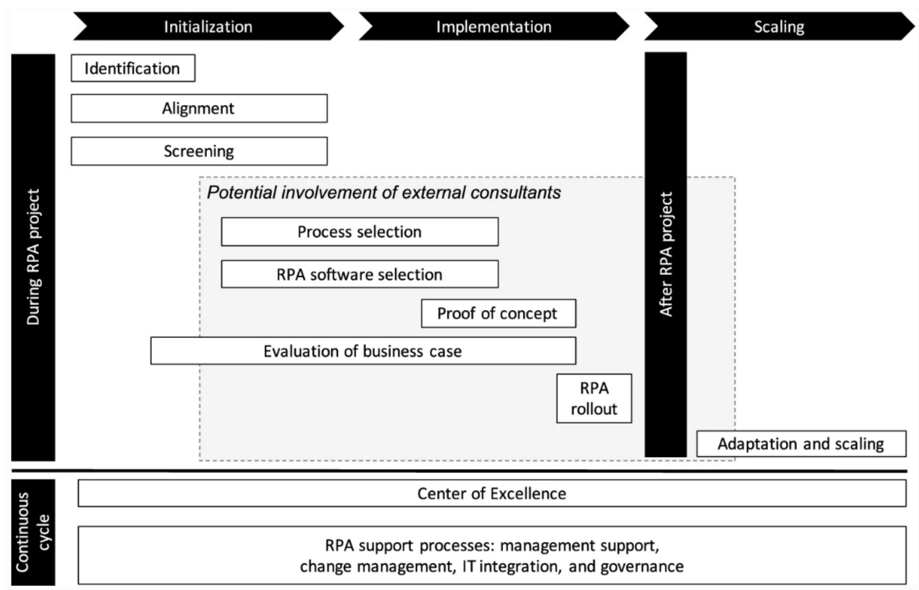


Figure 5.8: A Consolidated Framework for Implementing RPA Projects by [31].

In the dynamic roadmap designed by [50], the steps for a successful RPA implementation are identified. This roadmap is showed in Figure 5.9. The roadmap is not only focused on the robot that is developed, but as well on the structure that needs to be build by an organization to make the implementation successful. The roadmap consists of two phases, where the first is focussing on the identification of the business problem and setting up the proof of concept, while the second phase focuses on the development of the RPA bot and taking care of the complete RPA lifecycle. The roadmap is based on nine risk factors. The first two relate to the research conducted in this thesis, namely choosing the wrong processes and not carrying out the process assesment correctly. After completing the PLOST Framework, one still needs to start at the beginning of the Dynamic Roadmap. The benefit of already knowing what can be automated is that certain steps in the roadmap can be skipped. These are the steps "Identfiy Process for PoC" and "Are processes ready for Automation?". In the roadmap, not much attention is paid to how to find the processes and ensure they are ready. Therefore, the addition of the PLOST Framework to the Dynamic Roadmap helps increasing the chance of a successful implementation.

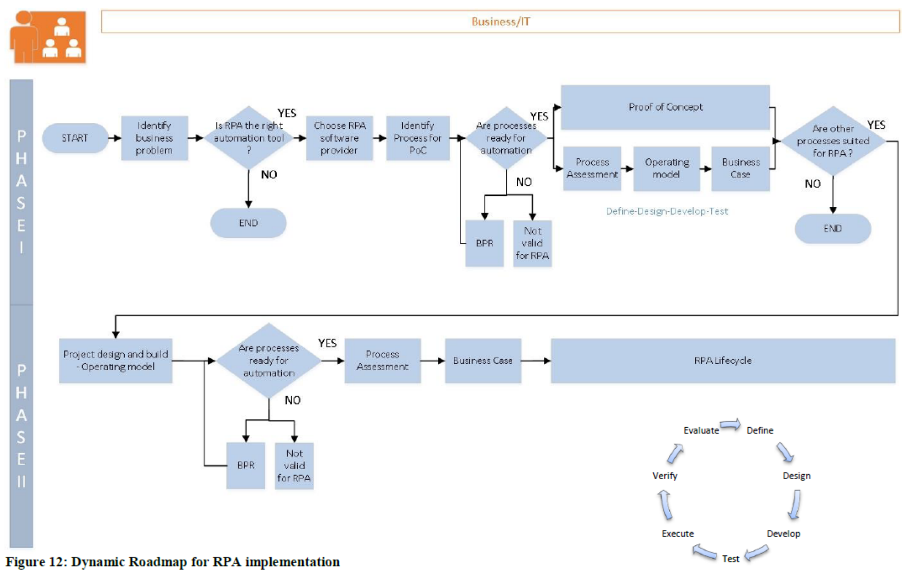


Figure 5.9: The dynamic roadmap for RPA implementation by [50].

Chapter 6

Evaluation - Case Study of the PLOST Framework

This chapter evaluates the PLOST Framework with a case study and thinking-aloud experiments. First, the framework is applied by the researcher, after which thinking-aloud experiments are conducted. Finally, the framework is adjusted according to the results of the evaluation of both. The goal of this chapter is threefold; the first is to make a prioritized list of tasks that are suitable to automate with RPA for the partner organization to test the applicability and effectiveness. The second is to evaluate the usability, practicality, and completeness of the framework by conducting thinking-aloud experiments with experts. The third is to incorporate the results of the evaluations into the enhanced PLOST^{+} Framework.

6.1 Case Study of the PLOST Framework at ProRail

This section describes how the PLOST Framework is put into practice. This is done with an application of the case study at ProRail, the partner organization. Each of the eight steps of the PLOST Framework is applied and the results are described in this section. After that, the results are evaluated and a plan to adjust the framework is set up.

6.1.1 Results of the Case Study

Step 1: Determine Automation Strategy

To determine the automation strategy, the business values need to be prioritized and the risk level has to be assessed. First, the business values prioritization took place. Different stakeholders at ProRail were asked for their opinion, which resulted in the prioritization in Figure 6.1. Six stakeholders gave their opinion about which value they thought deserved the highest prioritization.

Business value	S1	S2	S3	S4	S5	S6	Total
Time Savings	35	15	47	70	25	25	217
Quality & Accuracy Improvement	60	40	39	30	55	50	274
Availability & Flexibility Increase	5	45	14	0	20	25	109
Total	100	100	100	100	100	100	600

Figure 6.1: Prioritization of the business value made by stakeholders at ProRail.

Business value	Score
Time Savings	36,17
Quality & Accuracy Improvement	45,66
Improved Employee Satisfaction	18,17
Risk level	Low

Figure 6.2: Automation Strategy made by stakeholders at ProRail.

After the business values prioritization, the risk level was assessed. Together with the stakeholders, it has been decided to choose a low risk level. ProRail does not have experience with RPA yet and wants its first RPA implementation to be an example for the rest of the organization to look into RPA. To increase the chances of a successful implementation, the low risk level is chosen.

With the outcome of the business values prioritization and the decision on the risk level, the automation strategy is made and can be found in Figure 6.2. Because the total scores of the business values were quite high, this number is divided by the number of stakeholders. This does not only give the percentage of the different values but makes the calculation in the final step easier as well.

Step 2: Initial Process Collection

For this step, I conducted interviews with stakeholders at the partner organization are conducted to collect the initial processes for the framework. Section 3.2.2 explains what type of interviews is used and how the interviews are set up. The semi-structured interviews are done with different experts from ProRail, from departments that are related to the CSD. The identification and roles of the different interviewees can be found in Table 6.1. Because they all have their expertise and experience in the processes, this composition is chosen.

One of the interviewees shared his fears about the CSD employees not knowing exactly what the RPA is executing and when it would be implemented. His example to explain himself further was that when the RPA executed a script, after which the application failed, the CSD employee would not know the cause

Table 6.1: This table shows the roles that the different interview participants had and the amount of processes that resulted from the interviews.

#	Role	Outcome
1	Process leader CSD	3
2	IT Advicer & Operations	6
3	Manager CSD	1
4	Process leader at department of IMA & Proces Support	6

of the error. This was one of the reasons why he was not a supporter of automation. To reassure him, I explained that RPA bots never execute rules that they are not told to execute, which means the RPA developer exactly sets what the bot executes and what is not included will not be executed. Also when a RPA bot comes into a situation that was scripted, it stops automatically. Besides that, it can be ensured that there can always be an email sent to the CSD when a bot executes a script. This means the CSD can always be aware of what a RPA bot is doing. By talking about this topic with the interviewee, it became clear that besides the technical aspect of implementing RPA there is a human aspect as well. Guiding employees in how to cooperate with RPA is one of the socio-technical challenges called by [51] as well. I will not pay attention to that subject in this research, but it is definitely worth keeping this in mind when working with RPA as well.

During the four interviews, some participants started bringing up ideas about how something could be solved and turning the processes in that way, giving a wrong image of the current processes. For the framework, it is necessary to gather and understand processes as to how they are happening at the moment and not a fantasized way of how something could be done because that can not be automated. Appendix C show the details of the collected processes and whether they are already happening or not. An example of a process that is imaginary is process number eight. The participant of the interview explained that it would be helpful if the contact details were automatically copied from an information source into the ticket in the ITSM tool. This is not done manually at the moment but the executer just searches for this information. This means that there would be no information available in the IT systems on how this is done, because it is not executed.

Therefore, I first looked at whether the collected processes were processes that already existed. In Table 6.1, the column *Outcome* shows how many processes were collected during each interview.

Out of the sixteen collected processes, eight processes were processes that are happening, as can be seen in Appendix C. For three processes an attempt is made to let them happen and five processes were not existing but imaginary. For the eleven processes that exist or are attempted to execute, there was looked if they were achievable in the scope of this research. Table 6.2 shows the analysis of the feasibility of the processes. Out of this analysis, six processes are selected to keep in the initial process selection of the framework.

Table 6.2: Analysis if the existing processes are achievable to automate.

#	**Achievable?**	**Keep process?**
1	✓	✓
2	No because process is a sequel of process #1.	X
3	✓	✓
7	No because too general.	X
10	No because too general.	X
11	✓	✓
12	No because process is a sequel of process #13	X
13	✓	✓
14	No because too domain specific.	X
15	✓	✓
16	✓	✓

The six different processes in the initial process selection are summarized in Table 6.3.

Step 3: Mandatory Process Analysis

The next step is to analyze the processes regarding the mandatory process criteria. Figure 6.3 shows the mandatory process analysis of the six processes. Because the first four processes fail some of the mandatory criteria, they are removed from the framework and only processes five and six are left. These two processes together form the revised process selection.

Criteria	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Digital and structured input	✓	X	✓	X	✓	✓
Easy data access	X	X	X	✓	✓	✓
Few variations	X	X	✓	X	✓	✓
Repetitive	✓	✓	✓	✓	✓	✓
Rules Based	✓	✓	✓	X	✓	✓
Mature	✓	✓	✓	✓	✓	✓
Filtered away	✓	✓	✓	✓	X	X

Figure 6.3: Mandatory process analysis of the ProRail case study.

Table 6.3: The six processes in the initial process selection of the ProRail case study. The first number represents the new process number, while the second number represents the process number that was used in Table 6.2 and Appendix C.

#New	#Old	Process Description
1	1	The manual searching for the right incident handling scenario for the different incidents
2	3	Adding changes to the Marval ticket of an incident when a change is happening or done and the change(s) and incident are related.
3	11	Manually adding personal details for an access request for people related to a change when a change has been approved.
4	13	Send e-mail to OS (Operations Support) when a change has not yet been executed, but the change is prepared and the end time has arrived.
5	15	When having a priority 1 incident, sending a SMS via a web form to related people.
6	16	Creating a Marval ticket and solving the incident after receiving a NCSC notification by e-mail.

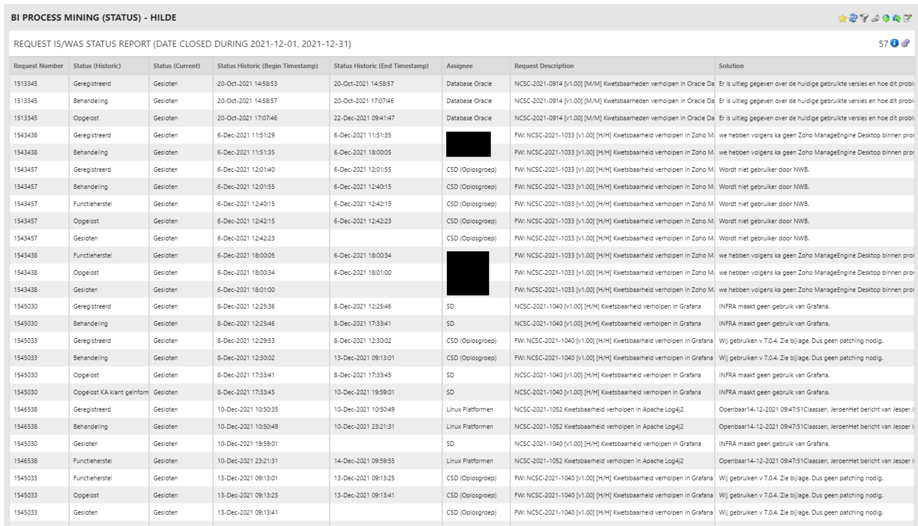
Step 4: Process Data Collection

The data of the two processes in the revised process selection is collected with the help of Xtraction [1]. This is IT business intelligence software made by Ivanti[2]. ProRail uses Xtraction as the report tool for Marval, their ITSM software. Xtraction provides multiple rules, grids, and graphical representations of data. This can be summarized in reports and dashboards, which can be scheduled so that the real-time data is sent by email or placed on a server. All the fields from Marval are available in Xtraction and new fields can be added as well.

Figure 6.4 shows some example data for process #16 in Xtraction. Some preparation needs to be done to be able to execute process mining techniques with this data. As discussed in Section 2.2, there needs to be a case, an activity, and a timestamp available in an event log to be able to apply process mining techniques. In the example data, a case can be found in the column *Request Number*, an activity in the column *Status (Historic)*, and a timestamp in the column *Status Historic (Begin Timestamp)*.

To collect the data for the two processes, different steps have been taken. For every process, a work list was made in Marval with all tickets for the two processes occurring between 16 May 2021 and 16 May 2022. Other filters for this data were that the type of the ticket equals *Incident*, the current status

[1] `https://www.ivanti.nl/products/xtraction`
[2] `https://www.ivanti.nl/`



BI PROCESS MINING (STATUS) - HILDE

REQUEST IS/WAS STATUS REPORT (DATE CLOSED DURING 2021-12-01, 2021-12-31) 57

Request Number	Status (Historic)	Status (Current)	Status Historic (Begin Timestamp)	Status Historic (End Timestamp)	Assignee	Request Description	Solution
1513345	Geregistreerd	Gesloten	20-Oct-2021 14:58:53	20-Oct-2021 14:58:57	Database Oracle	NCSC-2021-0914 [v1.00] [M/M] Kwetsbaarheden verholpen in Oracle Da	Er is uitleg gegeven over de huidige gebruikte versies en hoe dit probl
1513345	Behandeling	Gesloten	20-Oct-2021 14:58:57	20-Oct-2021 17:07:46	Database Oracle	NCSC-2021-0914 [v1.00] [M/M] Kwetsbaarheden verholpen in Oracle Da	Er is uitleg gegeven over de huidige gebruikte versies en hoe dit probl
1513345	Opgelost	Gesloten	20-Oct-2021 17:07:46	22-Dec-2021 09:41:47	Database Oracle	NCSC-2021-0914 [v1.00] [M/M] Kwetsbaarheden verholpen in Oracle Da	Er is uitleg gegeven over de huidige gebruikte versies en hoe dit probl
1543438	Geregistreerd	Gesloten	6-Dec-2021 11:51:29	6-Dec-2021 11:51:35	[redacted]	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	we hebben volgens ka geen Zoho ManageEngine Desktop binnen pror
1543438	Behandeling	Gesloten	6-Dec-2021 11:51:35	6-Dec-2021 18:00:05		FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	we hebben volgens ka geen Zoho ManageEngine Desktop binnen pror
1543457	Geregistreerd	Gesloten	6-Dec-2021 12:01:40	6-Dec-2021 12:01:55	CSD (Oplosgroep)	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	Wordt niet gebruiker door NWB.
1543457	Behandeling	Gesloten	6-Dec-2021 12:01:55	6-Dec-2021 12:40:15	CSD (Oplosgroep)	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	Wordt niet gebruiker door NWB.
1543457	Functieherstel	Gesloten	6-Dec-2021 12:40:15	6-Dec-2021 12:42:15	CSD (Oplosgroep)	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	Wordt niet gebruiker door NWB.
1543457	Opgelost	Gesloten	6-Dec-2021 12:42:15	6-Dec-2021 12:42:23	CSD (Oplosgroep)	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	Wordt niet gebruiker door NWB.
1543457	Gesloten	Gesloten	6-Dec-2021 12:42:23		CSD (Oplosgroep)	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	Wordt niet gebruiker door NWB.
1543438	Functieherstel	Gesloten	6-Dec-2021 18:00:05	6-Dec-2021 18:00:34	[redacted]	FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	we hebben volgens ka geen Zoho ManageEngine Desktop binnen pror
1543438	Opgelost	Gesloten	6-Dec-2021 18:00:34	6-Dec-2021 18:01:00		FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	we hebben volgens ka geen Zoho ManageEngine Desktop binnen pror
1543438	Gesloten	Gesloten	6-Dec-2021 18:01:00			FW: NCSC-2021-1033 [v1.00] [H/H] Kwetsbaarheid verholpen in Zoho M	we hebben volgens ka geen Zoho ManageEngine Desktop binnen pror
1545030	Geregistreerd	Gesloten	8-Dec-2021 12:25:36	8-Dec-2021 12:25:46	SD	NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	INFRA maakt geen gebruik van Grafana.
1545030	Behandeling	Gesloten	8-Dec-2021 12:25:46	8-Dec-2021 17:33:41	SD	NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	INFRA maakt geen gebruik van Grafana.
1545033	Geregistreerd	Gesloten	8-Dec-2021 12:29:53	8-Dec-2021 12:30:02	CSD (Oplosgroep)	FW: NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	Wij gebruiken v 7.0.4. Zie bijlage. Dus geen patching nodig.
1545033	Behandeling	Gesloten	8-Dec-2021 12:30:02	13-Dec-2021 09:13:01	CSD (Oplosgroep)	FW: NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	Wij gebruiken v 7.0.4. Zie bijlage. Dus geen patching nodig.
1545030	Opgelost	Gesloten	8-Dec-2021 17:33:41	8-Dec-2021 17:33:45	SD	NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	INFRA maakt geen gebruik van Grafana.
1545030	Opgelost KA klant geïnform	Gesloten	8-Dec-2021 17:33:45	10-Dec-2021 19:59:01	SD	NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	INFRA maakt geen gebruik van Grafana.
1546538	Geregistreerd	Gesloten	10-Dec-2021 10:50:35	10-Dec-2021 10:50:49	Linux Platformen	NCSC-2021-1052 Kwetsbaarheid verholpen in Apache Log4j2	Openbaar14-12-2021 09:47:51Claassen, JeroenHet bericht van Jesper i
1546538	Behandeling	Gesloten	10-Dec-2021 10:50:49	10-Dec-2021 23:21:31	Linux Platformen	NCSC-2021-1052 Kwetsbaarheid verholpen in Apache Log4j2	Openbaar14-12-2021 09:47:51Claassen, JeroenHet bericht van Jesper i
1545030	Gesloten	Gesloten	10-Dec-2021 19:59:01		SD	NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	INFRA maakt geen gebruik van Grafana.
1546538	Functieherstel	Gesloten	10-Dec-2021 23:21:31	14-Dec-2021 09:59:55	Linux Platformen	NCSC-2021-1052 Kwetsbaarheid verholpen in Apache Log4j2	Openbaar14-12-2021 09:47:51Claassen, JeroenHet bericht van Jesper i
1545033	Functieherstel	Gesloten	13-Dec-2021 09:13:01	13-Dec-2021 09:13:25	CSD (Oplosgroep)	FW: NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	Wij gebruiken v 7.0.4. Zie bijlage. Dus geen patching nodig.
1545033	Opgelost	Gesloten	13-Dec-2021 09:13:25	13-Dec-2021 09:13:41	CSD (Oplosgroep)	FW: NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	Wij gebruiken v 7.0.4. Zie bijlage. Dus geen patching nodig.
1545033	Gesloten	Gesloten	13-Dec-2021 09:13:41		CSD (Oplosgroep)	FW: NCSC-2021-1040 [v1.00] [H/H] Kwetsbaarheid verholpen in Grafana	Wij gebruiken v 7.0.4. Zie bijlage. Dus geen patching nodig.

Figure 6.4: Example data of process #16.

equals *Closed* and they are not archived.

After creating the work lists, they are exported as a CSV file. All the IDs for the requests are copied and used in Xtraction to filter on these IDs in a data source called *MSM12 X13 DM V1102 Request is/was Status Report*. All event data of these IDs is collected and again exported as a CSV file. The output is two CSV files for the two different processes.

Step 5: Process Mining

The two data files from the previous step are used to apply process mining techniques. Because Celonis offers a free academic account with clear guidance and a user-friendly interface, this process mining tool is chosen to use in this case study. Two data pools were created through a manual file upload. With this data, two process data models are made. For this, you first have to select the table, after which you have to configure the process data model. This implies selecting the *Case ID*, *Activity Name* and *Timestamp* and deciding if you want to sort on any column. After creating the two process data models, a workspace in the process analytics part can be created that uses such a process data model as a data source.

In the workspace, dashboards can be created. Standard options are available, like a process explorer, case explorer, and process overview, but dashboards can be set up manually as well. To gather the data needed in the upcoming steps, I created two templates for dashboards, one for processes and one for tasks. The dashboard of process five is called the SMS Prio 1 dashboard [3] and the

[3] `https://academic-h-e-jongeling-students-uu-nl.eu-2.celonis.`

dashboard of process six is called the NCSC Process Dashboard [4].

The template of the process dashboard contains the following widgets: 1. Process Explorer. 2. Variant Explorer. 3. Cycle Time. 4. Frequency (cases). 5. Frequency (activities). 6. Average events per case. 7. Number of variants. 8. Rework rate. 9. Automation rate.

Figure 6.5 shows the process dashboard of the SMS Prio 1 process in Celonis.

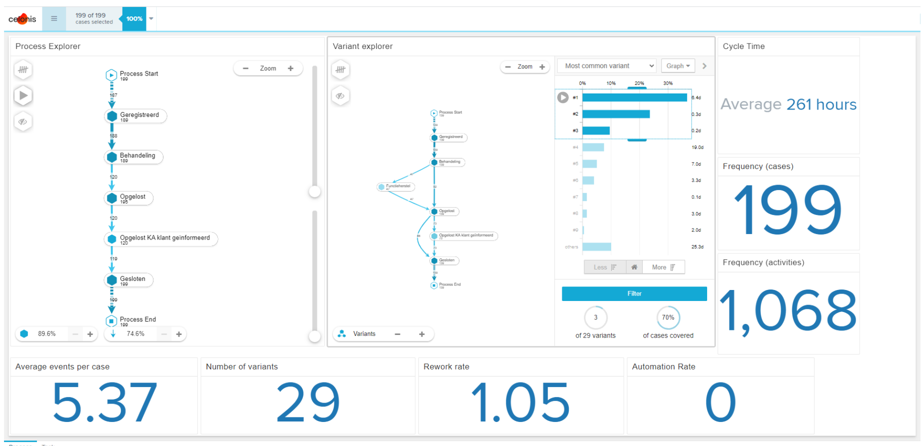


Figure 6.5: The process dashboard of the SMS Prio 1 process in the tool Celonis.

The template of the tasks dashboard contains two widgets with the following metrics: 1. Activities Frequency. 2. Case Frequency. 3. Duration in days. 4. Automation rate. 5. Rework rate. 6. Irregular Labor.

Step 6: Process Analysis

The partner organization has chosen a low risk level which means they want to automate a non-essential process with low complexity. Based on the process dashboards made with Celonis in the previous step, Table 6.4 is filled with the process analytics. The values for all seven criteria are collected for the two processes in the revised process selection. The processes are renamed from process five and six to *SMS Prio 1* and *NCSC* process.

Next, a decision can be made whether to keep both processes in the framework for the next step or filter one or two out. Because the chosen risk level is low, the values for the different criteria can be assessed accordingly. For each criterion, the best value is marked in the table with a green color. Whether a

---

cloud/process-mining/public/4a66e237-2080-456d-8ccd-c7e53a709f1f/#/frontend/documents/4a66e237-2080-456d-8ccd-c7e53a709f1f/view/sheets/2f2b4361-f028-4549-bf1f-55611dbbddeb

[4]https://academic-h-e-jongeling-students-uu-nl.eu-2.celonis.cloud/process-mining/public/980433f2-954c-4ae2-b383-e4fcead7e530/#/frontend/documents/980433f2-954c-4ae2-b383-e4fcead7e530/view/sheets/2f2b4361-f028-4549-bf1f-55611dbbddeb

higher or a lower value is better, depends on the chosen risk level. For the low risk level, a low value is marked as the best.

Table 6.4: Quantitative process analysis for the two processes in the ProRail case study.

Criteria	**SMS Prio 1 process**	**NCSC process**
Cycle Time	261 hours	273 hours
Case Frequency	199/year	100/year
Activity Frequency	1068	475
Standardization	29 variants	7 variants
Length	5.37	4.75
Automation Rate	0.00	0.00
Human Error Prone	1.05	1.01

As can be seen in Table 6.4, the SMS Prio 1 process has two colored cells, while the NCSC process has six colored cells. This means the latter matches the chosen risk level the best and therefore is further analyzed in the framework. This means the SMS Prio 1 process is eliminated.

Unfortunately, the performer of the tasks was not clearly described in the data. Therefore, the automation rate was for both processes zero. In this case study, it would not have made a difference in the outcome if one of the two processes had a higher or lower automation rate, but it is good to check already in the data collection step whether this data can be retrieved somewhere.

Step 7: Task Analysis

Based on the task dashboard created in Celonis, the task analytics of the NCSC process are extracted and shown in Table 6.6. The table shows the task numbers of the following corresponding tasks: 1. Geregistreerd. 2. Behandeling. 3. Wacht. 4. Functieherstel. 5. Opgelost. 6. Opgelost KA klant geïnformeerd. 7. Gesloten. 8. Heropen. The colors in the table represent the value of the cell regarding the other values in that row. Green means a high value and red is a low value. This color system helps by making the ranking in the next step.

This order is the chronological order that occurs in most of the process variants. Unfortunately, it is not possible in Celonis to show the tasks in a table in chronological order, only in alphabetical or in the highest value. Therefore, all the values have to be manually typed over from the dashboard.

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency	100,00	105,00	4,00	47,00	100,00	12,00	103,00	3,00
Case Frequency	100,00	100,00	4,00	47,00	100,00	12,00	100,00	3,00
Duration	0,00	4,49	16,43	2,86	4,00	4,11	0,02	3,61
Automation Rate	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Human Error Prone	1,00	1,05	1,00	1,00	1,01	1,00	1,03	1,00
Irregular Labor	0,27	0,27	0,00	0,33	0,64	0,00	0,44	0,00

Figure 6.6: Quantitative task analysis for the tasks in the NCSC process of the ProRail case study.

Step 8: Suitable Task Prioritization

The final prioritization is made with help of Table 5.3 from the previous step. The tasks in the table are ranked for each criterion from eight to one, as there are eight different tasks in the process. This ranking is shown in Figure 6.7. The scores of this table are multiplied by the output of the business values prioritization. The result of this calculation is the final prioritization of the tasks in the NCSC process, which is shown in Figure 6.8.

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency	6,00	8,00	3,00	5,00	6,00	4,00	7,00	2,00
Case Frequency	8,00	8,00	5,00	7,00	8,00	6,00	8,00	4,00
Duration	1,00	7,00	8,00	3,00	5,00	6,00	2,00	4,00
Automation Rate	8,00	8,00	8,00	8,00	8,00	8,00	8,00	8,00
Human Error Prone	5,00	8,00	5,00	5,00	6,00	5,00	7,00	5,00
Irregular Labor	5,00	5,00	4,00	6,00	8,00	4,00	7,00	4,00

Figure 6.7: Ranking of the tasks in the NCSC process of the ProRail case study.

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency	273,96	273,96	136,98	228,30	273,96	182,64	319,62	91,32
Case Frequency	365,28	365,28	228,30	319,62	365,28	273,96	365,28	182,64
Duration	36,17	253,19	289,36	108,51	180,85	217,02	72,34	144,68
Automation Rate	365,28	365,28	365,28	365,28	365,28	365,28	365,28	365,28
Human Error Prone	228,30	365,28	228,30	228,30	273,96	228,30	319,62	228,30
Irregular Labor	90,85	90,85	72,68	109,02	145,36	72,68	127,19	72,68
Total	1359,84	1713,84	1320,90	1359,03	1604,69	1339,88	1569,33	1084,90

Figure 6.8: The prioritization of the tasks in the NCSC process of the case study of ProRail.

This table can be interpreted as that the first task has the most business value to be automated first and the eighth task the least value. The outcome does not necessarily mean that the eighth task is not worth automating. Especially when this task is needed to automate another task, it could be that it has to be automated before another task.

6.1.2 Evaluation of the Case Study

In this section, the evaluation of the case study will take place, of which the results can be found in Table 6.5 as well. First, I discuss the positive results obtained during the case study. After that, two major adjustments are discussed that relate to the (1) level of detail of the data and the (2) data availability. Finally, three minor adjustments are listed. The goal of this discussion is to criticize the applicability and effectiveness of the framework to improve the next execution of the PLOST Framework.

Positive Aspects

In what follows, the positive results of the case study are listed. This is done while keeping in mind that the focus of the case study was on the applicability and effectiveness of the framework. Until the case study, the PLOST Framework only existed in theory. With the execution of the case study at the partner organization, it was evaluated whether the framework could be put into practice.

This execution of the case study shows that all the eight components of the PLOST Framework can be applied to a real-life case study. As input, a department of ProRail is taken that wants to automate some of their business processes. The output of applying the PLOST Framework is a ranking of the RPA candidate tasks with which ProRail can decide where to start automating.

Chapter 3 introduces the applicability as the extent to which the different steps of the framework could be applied in an industrial use case. As the case study showed that all the eight steps of the framework could be put into practice, the level of the applicability of the framework is good. Although all steps could be applied, some major and minor adjustments were identified to improve the framework for the next execution. These adjustments are listed in the following sections.

The effectiveness is described in Chapter 3 as whether the set objectives could be met with the framework. Regarding the two set objectives in Chapter 1.2, the framework meets both of them. It offers not only a new way of identifying and prioritizing task candidates for RPA but provides this to the partner organization as well to implement in any business use case.

Major Adjustments

In the following, two major adjustments to the framework are discussed that were identified during the case study. The first major adjustment is to add the option to choose for different levels of detail of the data. Because the tasks in the final step of the case study have a high-level, the output does not give back the exact rules needed to apply RPA. This is because the used ITSM data contains not the exact activities but more different statuses in the process. Therefore, it can be said that the framework identifies in this case study the status in which the automation could take place, rather than identifying the exact step. For further research, it would be interesting to apply the PLOST Framework with event log data that contains a lower level of detail.

The level of detail of the data can be identified in step four, where the process data is collected. By checking in this step if the desired level of detail is obtained, the output of the PLOST Framework can be aligned with the expectations of the execution. An adjustment to the framework is to add in step one an option to select which level of detail of the data is desired. This can be taken into account when collecting data in step four.

The second major adjustment is to add a data availability check. In step four the level of detail of the collected data should be checked but it is also recommended to already check if all the needed metrics can be obtained. During the process mining step, the automation rate could not be calculated because the required data was not available. When collecting the data, it could already be ensured that all the data needed to calculate the metrics is collected.

Minor Adjustments

Finally, three minor adjustments that resulted from the case study are discussed in this section.

The first minor adjustment is to change the calculation of the business values prioritization in step one. This is because the scores of the business values prioritization quickly become too high with more stakeholders. Therefore, it is sensible to divide the scores for the three business values by the number of stakeholders, then the total score always comes to 100. This makes the final calculation in step eight less complicated because the numbers are not that high.

The second adjustment is to prepare a clear interview strategy for the interviews in the second step of the framework. It is advised to make it clear what exactly you are looking for. When the participants are given too much freedom, they will come up with imaginary processes of how a process could be instead of telling about how processes are at the moment. This can be avoided by sticking to the interview template.

Another problem that raised during the interviews was that not every participant was a fan of automatization. By explaining that RPA does not take jobs but make work more challenging this problem was tackled. This was not something that could be adjusted in the framework but this socio-technical challenge is worth paying attention to when conducting interviews.

The last minor adjustment found during the case study was that it is the best to use the chronological order of process tasks in all the widgets of the process minings dashboards. This was in the case study not the case for the Celonis dashboards. When creating a table with all the metrics for the different activities, a choice can be made between alphabetical and vice versa. When analyzing them in the table of the framework, it is preferred to order them based on chronological order but this is not a possibility in Celonis. This gave some difficulties when typing over the values. This problem could be resolved by adding the order of the tasks in the framework, by using another process mining tool, or by using a formula that changes the other. For the latter option was no experience available at the time of the case study.

With this evaluation, adjustments to the framework are added in the enhanced PLOST^{+} Framework.

6.2 Thinking-Aloud Experiments

This section describes how the PLOST Framework is applied in two thinking-aloud experiments. What a thinking-aloud experiment is can be read in Section 3.2.3. The goal of the thinking-aloud experiments is to evaluate the usability, practicality, and completeness of the framework, which relates to RQ4. With the results of this evaluation, the framework can be adjusted. First, the set-up of the experiments is explained, after which the results are shared. This section ends with an evaluation of the results.

6.2.1 Set-Up of Thinking-Aloud Experiments

During the research, two thinking-aloud experiments were carried out. One with a RPA expert at an external company and one with a domain expert at the partner organization. Both participants signed a consent form before participating in the consent form, which states they participate voluntarily, agree with recording the experiment, and are aware that personal information will be anonymized. The consent form can be found in Appendix F.

The focus of the thinking-aloud experiments was on the usability and repeatability of the framework and not on the data. Because of practical reasons, this means that every experiment used the same data set. This was the same data set as used in the ProRail case study. Because the data was already gathered, some steps of the Framework did not have to be executed during the experiments, although it was important that the participants understood what happens in those steps. Therefore, these steps were still included in the tutorial. These concerns step two, four, and five, because in these steps respectively the processes are gathered, the data is collected and process mining is applied. This also means that the participants did not need to have process mining experience.

Before conducting the experiments the PLOST Framework was only tested by the researcher. Therefore, the experiments showed to which extent someone else can carry out the framework. Because this also depends on the clarity of the explanation, the tutorial was first tested on some associates of the researcher that had no experience in the domain or the topic. While executing the framework, they pointed out the unclear fragments in the framework. After altering this, the tutorial was ready to be used for the experiments.

Components of the Thinking-Aloud Experiments

During the thinking-aloud experiments, the participants walked through every step in chronological order with the goal to identify a prioritization of suitable RPA tasks. To be able to do this, the participants received the following components to be able to apply the PLOST Framework:

- A Tutorial: The tutorial, which can be found in Appendix G, guided the participant through the complete framework. It includes an introduction, context, explanation of the thinking-aloud experiment, and clear instruction on how to execute the eight steps. In this instruction, references are made to actions in the *Templates* file. The tutorial also explains what data was used and, for the steps that did not have to be executed by the participant, what happens in the step.

- Templates: The templates file is a CSV file with a tab for each step of the PLOST Framework and can be found in Appendix H. When a certain action was expected in the steps of the framework, the file offers a table where the action can be filled in. In this way, the execution of the framework was made as easy as possible.

- Celonis Dashboards: The participants of the thinking-aloud experiments received the same Celonis Process Analytics Dashboards as were used for the ProRail case study.

The participants received the components before the experiment started. Although the experiments took place offline, an online meeting was set up. This had two reasons: 1. the screen of the participant was shared so the researcher could watch on his screen. 2. the screen and conversation could be recorded. Those recordings were turned into transcriptions after the experiments took place. During the experiment, the researcher only explained information when the participant asked for anything. In general, they had to figure it out on their own with the tutorial.

Questions During and After Experiment

During and at the end of the experiment, the participants had to answer different questions. The questions at the end of the steps were asked to check the usability, practicality, and completeness. The usability questions were asked at the end of each step in which the participants had to execute something, so steps two, four, and five were excluded from the questions because the participants did not have to do anything in these steps. The usability was checked by asking the participant whether he thought the step was executable on a scale from one to ten, where one means not executable at all and ten is perfectly executable. The completeness was checked in the steps that included criteria, so in steps three, six, and seven. The participant was asked whether they thought the criteria in those steps were sufficient and if not, what they were missing. The practicality was only asked in step eight, with the question of what the participant thought of the number of calculations. Because this step was built by theory components and only tested by the researcher before, this question would show what the participants thought of the step.

At the end of the experiment, eight final questions were asked to determine again the usability, practicality, and completeness. The first question that was asked referred to the added value of process mining to the framework. With this question, the added value of process mining during the identification and prioritization of RPA candidates was determined. The second to the seventh question was linked to the usability and practicality of the framework. The last question referred to the completeness of the framework, as the participant was asked whether he would change or add anything to the framework and why.

The usability was also tested by following the actions and thoughts of the participants during the experiment. This gave a good idea of whether components were clear and easy to execute.

6.2.2 Results of Thinking-Aloud Experiments

In what follows, the results of the two thinking-aloud experiments are discussed separately. First, the comments of the experts gathered during the experiment are described step by step, after which a conclusion is given with the answers to the final questions.

Thinking-Aloud Experiment with RPA Expert

The first experiment was with an RPA expert from a consultancy company who had two years of experience in implementing RPA in business cases. The experiment took 53 minutes. The duration of the different steps varied quite because the RPA expert was triggered by the components to tell stories from practice. This was not a bad thing because those stories added value to how to apply the theoretical PLOST Framework in practice.

During the execution of the first step, he suggested adding the business value *Satisfied Employees*. The idea is that by automating tedious tasks, the employees are more challenged in their work which keeps them more enthusiastic. This is something his team takes into account when assessing the business value of a RPA implementation, as companies value this a lot. On the other hand, it could be argued that satisfied employees are a result of the other three business values and therefore not an isolated value. He thought that the risk level could have been better explained. The risk level is not something that the RPA expert and his team explicitly/consciously assess, but more something they keep in mind while selecting processes. Therefore, he was very curious about how this is assessed.

For some of the mandatory criteria, the opinion of the RPA expert was that if a process does not meet all criteria now but can meet them in the near future with some adjustments, the process should be taken into account as well. This applies for the criteria *Digital and Structured Input*, *Mature*, *Easy Data Access* and *Clear Rules*. Regarding *Digital and Structured* input, it could be the case that information is copy-pasted from an e-mail, but this information is not structured yet. By introducing a form, not only the sender of the e-mail benefits from the change but also the receiver because the task can now be automated. For *Mature*, the RPA expert said it depends on what the use case is. If an organization introduces a new process and wants from the start that the process is executed by a RPA bot, then that could be quite a good case. Especially with the shortage of employees at the moment. Therefore, *mature* could better be assessed in the sense of changes in the future than by the age of the process. Regarding *Easy Data Access* it could be that the needed data is not collected yet, but a database could be set up quickly to gather all the needed process data. Often the rules of a process are not yet known by employees executing the process. By organizing a meeting to discuss the rules, the criterion *Clear Rules* could be met. A criterion that is certainly mandatory in the eyes of the RPA expert is *Repetitive*. When a process is not repetitive, he would recommend writing it off immediately. The conclusion for this step is that if processes and their input of them can be redesigned to meet the criteria, they could be used further in the framework as well. Therefore, it is important to not throw away a process immediately when it does not meet all the criteria but assess whether it could be redesigned and if yes, keep them in an extra step of the framework. After all, the processes that meet all the mandatory criteria right away are still preferred over the ones that do not and are more worth analyzing first.

In step five, the RPA expert recognizes that the data is ITSM workflow data and he would recommend trying it in the future with log data as well because with ITSM data the activities are the same for each process.

The RPA expert noted that filling the table in step six was one of the tasks that could be automated with RPA and it was funny that he had to do it. Besides that, he shared that in practice the standardization of the process, so the amount of variants, really makes the difference in how complex a process is. Therefore, he agreed to use this as one of the criteria to measure the complexity of the different steps in the quantitative process analysis. Regarding the completeness of the criteria in this step, he said he did not miss anything. As an advantage of this step he mentioned that by using the quantitative criteria, the output is always objective. When his team discusses whether a process is complex or not, they all have their own opinion, and employees that execute a process also give subjective data. But when the cycle time is 262 hours, the value of that metric is fixed and cannot be discussed. When automating such a process, it can be calculated exactly how much time has been saved.

One of the criteria in step seven is *Irregular Labor* and this was something the RPA expert had not heard of before but thought was a good addition. He thought the step was easy but boring to execute. He found the depth level of the quantitative task analysis interesting and would like to see what the different tasks entail apart from the data. Now he was missing context with the data. Although this is definitely a good addition to the seventh step, it is difficult to achieve with the level of detail of the ITSM data as every process has the same activities.

The RPA expert agreed with the output from the PLOST Framework, as far as he could with the level of detail from the ITSM data. He remarked that the numbers of the output do not mean anything and this is good to keep in mind for the user of the framework. Besides that, he said the last step in the ranking was not something he would start automatizing as well, but this could definitely be something that needs to be automated in order to automate the complete process. The conclusion was that information was missing on how to interpret the output of the PLOST Framework and this could be improved.

Overall Experience of RPA Expert

In what follows, I give the answers of the RPA Expert to the final questions at the end of the experiment. This together forms the overall experience that the RPA expert had with the framework.

The RPA expert gave the addition of process mining to the identification of RPA candidates an eight because it offers a lot of data on which you can base objective choices. This helps when having to convince the management of an organization of the benefits of a RPA implementation. Because management does not always know exactly about the operations of a team, showing statistics helps get approval. The overall experience of the RPA expert was that the framework was clear and standardized, meaning it could be easily used in other organizations or use cases. The duration was good but he thought the last two steps were boring to execute and could be automated more. What he valued the most from the framework, was the combination of business, qualitative and quantitative data and how the steps got more specific and detailed. Besides that, he experienced that the framework was easy to execute, which is one of its plusses. What could be improved did he already tell during the steps but was mostly how to interpret the output of the framework.

Thinking-Aloud Experiment with Domain Expert

The second experiment was with a domain expert from the partner organization ProRail who had one year of experience with the processes at the CSD. This experiment took 38 minutes. The execution of the steps did not differ that much in length because the domain expert was not saying that much during the experiment. Therefore, the questions at the end of the experiment helped with the extraction of thoughts from the domain expert.

Overall Experience of Domain Expert

In the following, I describe which answers the domain expert gave to the questions asked at the end of the experiment. This shows what his overall experience with the framework was.

The domain expert had a good experience with the framework and thought all steps were easy to execute, especially with the help of the tutorial. He missed some background information for some steps, for example, the steps with the criteria. This is understandable since a choice had to be made regarding what to tell in the tutorial so the participants would understand what to do but it was not too long. He gave the addition of process mining to the framework a seven. This is because ProRail is not mapping its processes accurately at the moment, but in order to do so sufficient data should be available and that is not the case with the ITSM data. Therefore, he would give a higher grade when better event data is used and the benefits of process mining are clearer. What he valued the most in the framework, were the Celonis dashboards and the tables in the last step. These tables in Excel automatically transferred all the data and colored greener when the final output was higher on the ranking.

6.2.3 Evaluation of the Thinking-Aloud Experiments

In the following section, I evaluate the results of the thinking-aloud experiments while keeping in mind the focus for this is on the usability, practicality and completeness of the framework. First, the positive aspects of the framework that were identified by the experts are discussed. After that, two major improvements are discussed that relate to (1) redesigning processes and (2) the final ranking. The section ends with three minor adjustments.

Positive Aspects

To kick off with the positive feedback, it can be said that the participants valued how easy it was to carry out the framework. They also appreciated that it first focuses on the business side, then carries out a qualitative check, and finishes with a quantitative analysis. Especially because such quantitative analysis is objective and helps convince the higher management of an investment into RPA.

Besides that, they mentioned that a plus of the framework is that is standardized and can therefore easily be applied in other organizations or use cases. Because the usability was descried as the extent to which an artifact can be used by users to achieve specified goals in a specified context of use, this implies that the usability of the framework is high.

The practicality is seen as how executable the framework is for the participants. By completing the whole experiment, they showed that the framework can be put into practice by someone else than the researcher. They had no problems with the duration of the framework, although the copy-paste parts were boring from time to time. Regarding the addition of process mining, they rated this with an average of 7.5, which could be improved by changing the level of detail of the process mining data. This means the practicality is good as well.

This brings us to the last criterion the experts were given, namely completeness. The completeness is interpreted as whether the different components of the framework are complete and do not miss any information. The experts mentioned for most of the steps that the right set of criteria was used and the steps looked good. Nevertheless, they did mention some adjustments to some components as well. These major and minor adjustments are listed in the upcominig sections.

Major Adjustments

During the thinking-aloud experiments two major adjustments were identified that will be discussed here.

The first major adjustment is to add a redesign step to the framework. During the experiments, some processes did not meet all the mandatory criteria in the third step and were therefore removed from the framework. It could be that after a redesign of the framework, a process meets all the criteria and is suitable to remain in the framework. The RPA expert advised to not apply this when the criterion *Repetitive* was not met because this is in his eyes definitely a mandatory criterion that cannot easily be changed.

The second major adjustment is to add a final ranking list to the last step of the framework. Both experts stated that more information about the final ranking would be desirable. This relates not only to how the ranking is presented but also to how it can be interpreted. The ranking now ends with a meaningless score and it is good to mention that this score has no added value and is purely intended for the ranking.

Minor Adjustments

In what follows, the three minor adjustments that were found during the experiments are discussed.

The first minor adjustment is to add *Satisfied Employees* as a business value to the automation strategy of the first step. The RPA expert mentioned that they used *Satisfied Employees* as a business value when starting with a RPA project. The RPA Suitability Framework, which is described in Section 4.2, uses this as a business value as well. Although this was found as a possible adjustment to the framework, the decision has been made to not include it in this research as no metrics in the task analysis are avaiable to connect with. Future work could explore the benefits of adding this business value to the automation strategy.

The second minor adjustment is to change the description of the mandatory criterion *Maturity* in the third step. This was first described as depending on the age of the process as well, but the RPA expert explained that the stability of the process is more important than how long a process has been there.

The last minor adjustment has been found in the level of detail of the data used in the research. This adjustment has been identified as well in the case study. In the fifth step the RPA expert mentioned that all the activities were the same for each process and therefore, the level of detail of the data was not sufficient enough. He advised me to check this earlier in the framework and was curious how the results will be when applying the PLOST Framework with more detailed data. This relates to the remark of the domain expert in step seven. He said he would have liked more context to what the tasks entail. This is missing now due to the level of detail of the data as well because with more detailed data it would have been clear what the exact activities in a process are. This would still be a short description, such as ”complete web form”, but this would already give some more context to the activities.

6.3 RPA Implementation of the output of the PLOST Framework

The last evaluation method of the PLOST Framework is to implement the output of the PLOST Framework. This means automating the task that came out of the PLOST Framework as the best suitable task to automate with RPA. To do this, a RPA tool of own choice can be used.

Unfortunately, the output of the case study did not consist of a task with concrete rules to automate. The framework identified in the case study more the best phase in which the automation could take place. This could also be the desired output if due to time limitations the data available needs to be used. But when an organization desires to obtain the exact rules of a task, it is recommended to gather more detailed data. This can be done by creating UI Logs, as explained in the method by [16]. Due to time constraints, no UI logs were created in this research, which makes it not possible to implement a RPA solution.

This means the effectiveness of the PLOST Framework could not thoroughly be tested. Future research could focus on obtaining UI logs to make it possible to test whether the output of the framework is automatable.

6.4 The PLOST$^+$ Framework

In this section, I iterate back to the designing phase to alter the PLOST Framework with the adjustments that came out of the evaluation of the case study and the thinking-aloud experiments. First, a summary of the results of the case study and the thinking-aloud experiments is given. Then, the enhanced PLOST$^+$ Framework is shown, after which the added components are explained in detail. The PLOST$^+$ Framework will not be executed in this research, but this is left to further research.

6.4.1 Summary of Results

The positive aspects and adjustments that resulted from the evaluation of the case study and the thinking-aloud experiments are summarized in Table 6.5. All the four major adjustments will be processed in the PLOST$^+$ Framework. The minor adjustments will not all be put into work, as they are not all that important or do not fit into the scope of this research. The minor adjustments that will be processed are the first two of the case study and the second one of the thinking-aloud experiments.

Table 6.5: Overview of the results of the evaluation. The adjustments in bold text are incorporated in the PLOST$^+$ Framework.

	Case Study	**Thinking-Aloud Experiments**
Positive aspects	• All eight steps can be executed in a real-life business case • Desired output is obtained	• Easy to carry out • Standardized • Combination of business, qualitative, and quantitative
Major adjustments	• **Decide on the level of detail of data** • **Add additional data check**	• **Redesign processes to meet mandatory criteria** • **Add final ranking**
Minor adjustments	• **Calculation of business values prioritization** • **Clear interview strategy** • Order of activities in Celonis	• Add Satisfied employees as business value • **Change description of maturity** • Execute with more detailed data

6.4.2 Overview of the PLOST$^+$ Framework

The PLOST$^+$ Framework is shown in Figure 6.9, with two additional but optional substeps added and highlighted in grey. The exact content of the eight basic steps has changed compared to the initial framework and this will be explained further in Section 6.4.3. Step four was first seen as a qualitative step, but after conducting it in the case study it was decided that it would better suit to the quantitative type.

6.4.3 Detailed Description of the PLOST$^+$ Framework

This section explains the adjustments incorporated in the PLOST$^+$ Framework in detail. These additions were based on the evaluation of the case study and the thinking-aloud experiments in this chapter.

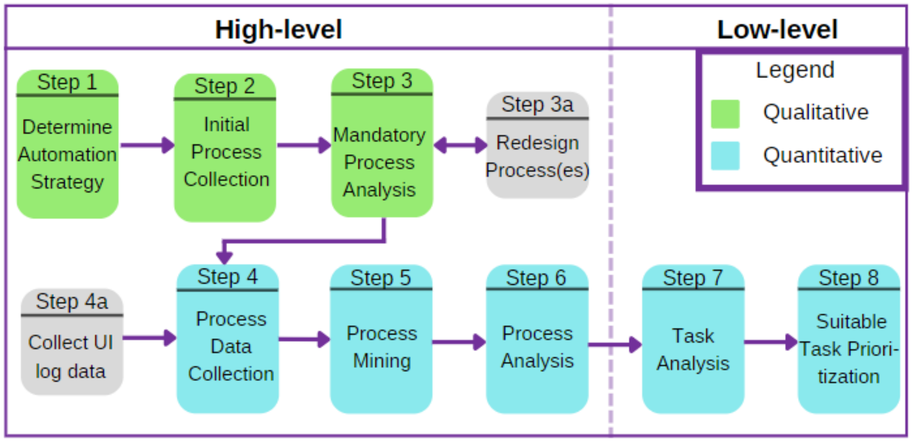


Figure 6.9: The PLOST^{+} Framework.

Step 1: Determine Automation Strategy

Besides the prioritization of the business values and the determination of the risk level, the selection of the level of detail of the output is added to step one. For this selection, the organization has a choice of a detailed outcome or an abstract outcome. With the detailed outcome, the organization will know exactly which task has to be automated and what the rules for the RPA bot are. With the abstract outcome, the organization obtains a direction in which phase of the process the automation should take place. The first option is recommended when the organization wants to use the framework to immediately implement RPA with the output of the framework, and the time and investment needed to collect the right data is no issue.

The second adjustment that is made in this step, is that for the final scores of the business value prioritization the average of the scores by the different stakeholders is taken. This makes the final calculation in step eight easier to execute because the numbers are less high.

Step 2: Initial Process Collection

Not many changes in this step, except that extra emphasis is placed on asking in the interviews about the current status of the business processes instead of how the participant would like the process to be. This avoids extra work afterwards regarding the filtering between real and imaginary processes.

Step 3: Mandatory Process Analysis

In the third step, the description of the criteria *Mature* is changed. The sentence that the process already should exist some time is deleted because a new process can be automated as well, as long as it is not prone to changes in the near future.

Besides that, substep 3a is added. In this step, processes that do not yet meet all the mandatory criteria are saved and redesigned if possible. The reason for this is that it could be the case that a good automation use case does not yet meet all the mandatory criteria, but will do that with some small changes. To not immediately disregard these processes, they are saved and redesigned in the new substep. Preference is still given to processes that directly meet all the mandatory criteria, as redesigning the process costs extra time.

Step 4: Process Data Collection

The desired level of detail of the output is taken into account in this step by gathering the right type of data. When the desired output is abstract, data with a lower detail level can be used like the ITSM data in the ProRail case study. When the desired output is detailed, data with a high detail level should be gathered. This means the exact tasks that are executed.

If this data is not available at the organization, UI logs can be created with recordings of the different systems. For the creation of these UI logs, substep 4a is added to the framework. In this research, it is out of scope to explain how exactly to obtain UI logs, but this has been performed in the method by [16].

The last addition to this step is to check if the data for all the metrics are available. In the case study, the automation rate could not be calculated because the performer of the tasks was not known. By checking in the data collection step whether this data could be retrieved somewhere, the chance is higher than all the criteria in the quantitative steps could be calculated.

Step 7: Task Analysis

The only adjustment in this step is to give more context to the tasks if this information is available. The higher the level of detail of the process data, the more information can be given about what a task exactly is about.

Step 8: Suitable Task Prioritization

In the last step, an addition has been made in the sense of an extra twist to the output. In the initial version of the framework, the output was a table with as last row values that were colored more bright if they were ranked higher. Out of the evaluation came that this was not clear enough, therefore this row is turned into a final ranking overview. An example of the ranking of the ProRail case study is shown in Table 6.6.

This final ranking goes together with extra information on how to interpret the output. It is emphasized that the number of the output does not have a meaning, but is solely used to create the ranking.

Table 6.6: Ranking of the final prioritization of the ProRail case study.

Ranking	**Task**	**Score**
1	T2	1713,84
2	T5	1604,69
3	T7	1569,33
4	T1	1359,84
5	T4	1359,03
6	T6	1339,88
7	T3	1320,90
8	T8	1084,90

Chapter 7

Discussion

This chapter starts with looking back at the research questions as stated in Section 1.1 and how they have been answered in this research. With the answers to these research questions, the main research questions can be answered. After that, this chapter addresses the contributions that are made with this research and the limitations, the limitations of the research, and it ends with a recommendation for future work.

7.1 Research Questions

7.1.1 RQ1 Existing Approaches

How do existing approaches select candidates suitable for RPA and what are the criteria used?

In Chapter 4 four methods have been studied in-depth in how they select suitable RPA candidates. For each method, first, a short introduction is given. After that, the components of the methods are investigated, and last, the benefits and limitations of the methods are listed. The four methods all differ in the combination of their LoD versus their type of analysis. None of the methods met all the three criteria set in Section 1.2, which shows there is room for improvement.

Also, the criteria of the four methods are analyzed, which resulted in Table 4.4. In this analysis, 34 unique criteria are involved together with some characteristics, e.g. the mandatoriness, the LoD, and the type of analysis.

7.1.2 RQ2 Benefits of the Addition of Process Mining

How can the existing RPA candidate selection approaches benefit from the addition of process mining techniques?

Chapter 4 shows for the four analyzed methods how they scored regarding the set criteria of Section 1.2 and how they can be improved to meet them all. Only one of the four methods makes use of process mining techniques. This method offers insight into which components to use to build a method that includes process mining techniques. With this knowledge and the criteria overview in Table 4.4 a framework could be constructed.

7.1.3 RQ3 Proposed Framework

RQ3: What framework can be constructed to select suitable RPA candidates in ITSM processes?

To answer RQ3, the PLOST Framework is constructed and introduced in Chapter 5. It builds upon different components of the four researched methods and introduces some new components as well. The framework consists of eight steps that differ in whether they are qualitative or quantitative and if they are focused on the high-level or the low-level. The output of the framework is a prioritized list of tasks that are suitable for RPA based on the automation strategy of the organization.

7.1.4 RQ4 Evaluation with Experts

RQ4: How do experts experience the proposed framework regarding usability, practicality and completeness?

The PLOST Framework is evaluated with a case study and two thinking-aloud experiments in Chapter 6. The goal of the case study was to test the applicability and effectiveness of the framework. Although all four steps were successfully performed, the effectiveness could not fully be evaluated as the output of the framework was not yet possible to automate. This was due to the level of detail of the ITSM data, which shows that standard ITSM data is not sufficient to identify exact rules to automate but rather phases in which automation could take place.

The two thinking-aloud experiments were conducted with a RPA expert and a domain expert and the goal of these was to evaluate the usability, practicality, and completeness of the framework. The usability was highly rated, as the participants thought it was easy to execute and it was standardized so that it could be applied in different use cases. By being able to carry out all the steps of the framework, the participants showed the practicality of the framework is high as well. Regarding completeness, some remarks were given, but the experts generally thought the criteria were complete and not missing anything. The experts valued the addition of process mining to the framework with a 7.5, especially because this offers an objective, quantitative analysis in addition to the qualitative part in the beginning. According to the experts, this could help convince the higher level of an organization of the benefits of a RPA implementation.

The grade could be improved by applying the framework to more detailed event data.

The case study and the experiments resulted in adjustments to the framework that were subsequently incorporated into the enhanced PLOST$^+$ Framework, which can be found in Chapter 6.4.

7.1.5 MRQ Process Mining to Identify RPA Candidates

How can process mining techniques systematically be used to identify candidates to automate with RPA within ITSM processes?

With the help of the PLOST Framework designed in this research, users are able to identify and prioritize suitable RPA candidates. By first understanding the concepts of RPA and process mining, the possible cooperation between the two could be studied. After that, four different methods that identify suitable RPA candidates were analyzed in-depth through literature research. All these methods used their own set of criteria to get this done. These criteria were focused on qualitative or quantitative analysis and on the high- or low-level of a process. By creating an overview of all the criteria, the final set of criteria for the proposed framework could be made that consists of both qualitative and quantitative analysis and high- and low-level criteria.

Only adding process mining to a framework would result in a time-consuming product, as this would mean one has to gather all the process data of the studied processes. By adding a qualitative analysis to the framework before the quantitative analysis takes place, time and effort are saved because process mining is only applied to relevant processes.

With the evaluation of the PLOST Framework, it is shown that process mining techniques can systematically be added to a framework that identifies and priorities RPA candidates. Unfortunately, the output of the framework could not yet be automated with RPA, as it was not detailed enough. Instead, it identified in which phase to search for the automation. This showed that process mining delivers relevant metrics regarding processes and tasks whether they could be suitable for RPA or not, but the effectiveness needs to be thoroughly tested yet.

7.2 Contribution to the Field of RPA and Process Mining

The PLOST Framework is created to offer a possibility to identify and prioritize suitable RPA candidates. Its biggest contribution is the combination of both qualitative and quantitative analysis while operating on both the high- and low-level of business processes. Besides that, it takes into account the automation strategy of an organization throughout the framework, which was not included in other sources researched in this study.

Another contribution is the application of ITSM data. Although the case study shows that a higher level of detail needs to be obtained in order to extract RPA rules, the easy access to ITSM data when using an ITSM tool makes it possible to quickly implement this framework.

Another contribution of this research is that the metrics of tasks from different processes can be compared with each other. When executing the last two steps in the framework with multiple processes, the framework can compare if task A from process one is more suitable to automate than task B from process two. This was something that was not seen before in the studied literature.

7.3 Limitations

The limitations section is split into three parts. First, the limitations of the PLOST Framework are discussed, then the limitations of the case study are discussed and it ends with the limitations of the thinking-aloud experiments.

7.3.1 PLOST Framework Limitations

After the creation of the PLOST^{+} Framework, it was not applied again due to time constraints. After applying the new composition of the framework, the applicability and effectiveness need to be evaluated again.

Besides that, the PLOST Framework is only applied in one case study. It needs to be tested more extensively in different organizations and case studies to develop further.

7.3.2 Case Study Limitations

The main limitation of the case study was that the outcome of the case study did not consist of a concrete task to automate but rather a phase in which automation can take place. Because of this, the execution of the RPA implementation could not continue and therefore, the effectiveness of the framework could not be evaluated. That the output of the framework is not directly ready to be automated does not have to be a problem, if that is what the desired output is. This can be the case when there is limited time and the framework is just used to scan which phase in an ITSM process is the most suitable to further investigate. In that case, the ITSM data can be used as was done in the case study, which can be easily obtained if the organization makes use of an ITSM tool.

When the desired output is to extract the exact task to automate, the initial version of the frameworks lacks to produce this. In the enhances PLOST^{+} Framework , this limitation is tackled by adding an extra substep that creates a UI log of the ITSM tool. Because of time constraints, this new step was not executed. When automating the first task on the prioritized list of suitable tasks, it can be seen if the prioritization is successful or not. This would significantly raise the validity of the framework.

7.3.3 Thinking-Aloud Experiment Limitations

The thinking-aloud experiment was conducted with two experts. Although these gave interesting and helpful insights, the evidence of the usability, practicality, and completeness of the framework would have been stronger if the experiments were conducted with more experts.

An important opinion that is missing in this research is from the process mining expert. By conducting an experiment with someone who has plenty of experience with the application of process mining, the steps that are related to process mining could have been checked on completeness and correctness. Besides that, he or she could have given advice on how to introduce process mining in an organization that is new to this concept. This might make it easier to collect the desired process data while doing a RPA project.

Another limitation of the thinking-aloud experiments was that the two experts only executed certain steps of the framework. Due to practical and time constraints, the steps that included the process gathering, data collection, and applying process mining were already conducted for them. Although a description was given to them of what was done in these steps, it would probably have been different if they would execute these steps by themself as well.

7.4 Future Work

The insights into the limitations of this research offer an opportunity for possibilities in the future as well. First of all, further research could apply the PLOST^{+} Framework to a different organization and situation. In this execution, UI logs can be made to get a detailed output from the framework. This output could then be actually automated to evaluate the complete effectiveness of the framework. Generating UI logs within the framework will result in new results regarding the usability, practicality and completeness of the framework. Therefore, it is recommended to keep iterating back to the development phase so the framework improves with every application. In addition, future studies regarding the socio-technical challenges that arise with the implementation of RPA would be worthwhile. Automating a task is not only something that has a technical side, because employees need to work differently as well. How to best manage the expectations, the change management, and the fear of losing jobs are just three examples of socio-technical challenges that need attention to make RPA implementations successful.

Chapter 8

Conclusion

The research in this thesis focused on how to systematically use process mining techniques to identify and prioritize candidates within ITSM processes to automate with RPA. Although different approaches exist to identify RPA candidates, they are often time-consuming and focus on either quantitative or qualitative analysis but not both. Besides that, these methods highlight only the high- or low-level but again not both. Therefore, there is a lack of a framework that combines both qualitative and quantitative analysis and highlights both the high- and low-level.

This research gap is answered by introducing the PLOST Framework, a framework that creates a Prioritized List Of Suitable Tasks for RPA. This framework was built on a variety of components of already existing methods. The difference between the PLOST Framework and the existing ones is that the proposed framework combines both the qualitative and quantitative components and the high- and low-level. This development was created after conducting in-depth literature research.

The PLOST Framework starts with the creation of an automation strategy that determines the output of the framework based on the demands of the organization. This strategy gives guidance throughout the framework in making decisions. After that, processes are collected and assessed against six mandatory qualitative criteria. The next step is to collect process data and apply process mining techniques to this. With the analytics that comes out of the process mining, first, quantitative process analysis is conducted, after which a quantitative task analysis follows. The last step is to create a prioritized list of suitable RPA tasks based on the task analysis and the automation strategy.

The PLOST Framework was applied to a case study at ProRail, the partner organization. The output of this case study was evaluated and out of this came different adjustments for the framework. Then the case study was transformed into data for two thinking-aloud experiments, one with a RPA expert and one with a domain expert. In these thinking-aloud experiments, the framework was evaluated against its usability, practicality, and completeness. The framework scored high on the first two concepts and especially the addition of process mining to the identification of RPA candidates was valuable. Besides that, the combination of qualitative and quantitative aspects was mentioned as a benefit as well. Regarding the completeness of the framework, the experts had some comments, which were then incorporated into the enhanced $PLOST^+$ Framework.

Bibliography

[1] Wil van der Aalst. “Business process management: a comprehensive survey”. In: *International Scholarly Research Notices* 2013 (2013).

[2] Wil van der Aalst. “Data science in action”. In: *Process mining*. Springer, 2016, pp. 3–23.

[3] Wil van der Aalst. “Process Mining and RPA: How To Pick Your Automation Battles?” In: *Robotic Process Automation: Management, Technology, Applications. De Gruyter* (2021), pp. 223–239.

[4] Wil van der Aalst, Ton Weijters, and Laura Maruster. “Workflow mining: Discovering process models from event logs”. In: *IEEE transactions on knowledge and data engineering* 16.9 (2004), pp. 1128–1142.

[5] Björn Agaton and Gustav Swedberg. “Evaluating and Developing Methods to Assess Business Process Suitability for Robotic Process Automation-A Design Research Approach”. MA thesis. 2018.

[6] Simone Agostinelli, Marco Lupia, Andrea Marrella, and Massimo Mecella. “Automated generation of executable RPA scripts from user interface logs”. In: *International Conference on Business Process Management*. Springer. 2020, pp. 116–131.

[7] Simone Agostinelli, Marco Lupia, Andrea Marrella, and Massimo Mecella. “SmartRPA: A Tool to Reactively Synthesize Software Robots from User Interface Logs”. In: *International Conference on Advanced Information Systems Engineering*. Springer. 2021, pp. 137–145.

[8] Hamza Alshenqeeti. “Interviewing as a data collection method: A critical review”. In: *English linguistics research* 3.1 (2014), pp. 39–45.

[9] Aleksandre Asatiani and Esko Penttinen. “Turning robotic process automation into commercial success–Case OpusCapita”. In: *Journal of Information Technology Teaching Cases* 6.2 (2016), pp. 67–74.

[10] Adriano Augusto, Raffaele Conforti, Marlon Dumas, Marcello La Rosa, Fabrizio Maria Maggi, Andrea Marrella, Massimo Mecella, and Allar Soo. “Automated discovery of process models from event logs: Review and benchmark”. In: *IEEE transactions on knowledge and data engineering* 31.4 (2018), pp. 686–705.

[11] Official Accreditor von ITIL AXELOS. *ITIL® Service Transition*. 2011.

[12] Lars Berghuis. “Using the Wisdom of the Crowd to Digitalize: Designing a workshop-based process selection method for the identification of suitable RPA processes.” MA thesis. University of Twente, 2021.

[13] Richard Breton and Éloi Bossé. *The cognitive costs and benefits of automation*. Tech. rep. DEFENCE RESEARCH and DEVELOPMENT CANADAVALCARTIER (QUEBEC), 2003.

[14] Andrew Burgess. *The Executive Guide to Artificial Intelligence: How to identify and implement applications for AI in your organization*. Springer, 2017.

[15] Panagiota Chatzipetrou, Lefteris Angelis, Per Rovegård, and Claes Wohlin. “Prioritization of issues and requirements by cumulative voting: A compositional data analysis framework”. In: *2010 36th EUROMICRO Conference on Software Engineering and Advanced Applications*. IEEE. 2010, pp. 361–370.

[16] Daehyoun Choi, Hind R’bigui, and Chiwoon Cho. “Candidate Digital Tasks Selection Methodology for Automation with Robotic Process Automation”. In: *Sustainability* 13.16 (2021), p. 8980.

[17] Daehyoun Choi, Hind R’bigui, and Chiwoon Cho. “Robotic Process Automation Implementation Challenges”. In: *International conference on smart computing and cyber security: strategic foresight, security challenges and innovation*. Springer. 2020, pp. 297–304.

[18] Wade Cook and Moshe Kress. “A multiple-criteria composite index model for quantitative and qualitative data”. In: *European Journal of Operational Research* 78.3 (1994), pp. 367–379.

[19] Leffingwell Dean and Widrig Don. *Managing software requirements: A use case approach*. 2003.

[20] Boudewijn van Dongen and Wil van der Aalst. “A Meta Model for Process Mining Data.” In: *EMOI-INTEROP* 160 (2005), p. 30.

[21] Boudewijn van Dongen, Ana de Medeiros, Eric Verbeek, Ton Weijters, and Wil van der Aalst. “The ProM framework: A new era in process mining tool support”. In: *International conference on application and theory of petri nets*. Springer. 2005, pp. 444–454.

[22] Jenny Dugmore and Sharon Taylor. “ITIL® V3 and ISO/IEC 20000”. In: *The Stationery Office* (2008), pp. 2–5.

[23] Marlon Dumas, Marcello La Rosa, Jan Mendling, and Hajo Reijers. *Fundamentals of business process management*. Vol. 1. Springer, 2013.

[24] Vahid Garousi, Michael Felderer, and Mika Mäntylä. “The need for multivocal literature reviews in software engineering: complementing systematic literature reviews with grey literature”. In: *Proceedings of the 20th international conference on evaluation and assessment in software engineering*. 2016, pp. 1–6.

[25] Jerome Geyer-Klingeberg, Janina Nakladal, Fabian Baldauf, and Fabian Veit. "Process Mining and Robotic Process Automation: A Perfect Match." In: *BPM (Dissertation/Demos/Industry)*. 2018, pp. 124–131.

[26] Hans-Christian Grung-Olsen. "A strategic look at robotic process automation". In: *BP Trends* (2017).

[27] Christian Günther and Wil van der Aalst. "Fuzzy mining–adaptive process simplification based on multi-perspective metrics". In: *International conference on business process management*. Springer. 2007, pp. 328–343.

[28] Sugandha Gupta. "A comparative study of usability evaluation methods". In: *International Journal of Computer Trends and Technology* 22.3 (2015), pp. 103–106.

[29] Wytze Jan Haan. "How can process mining be used to identify Robotic Process Automation opportunities?" B.S. thesis. University of Twente, 2021.

[30] Wytze Jan Haan. "How can process mining be used to identify Robotic Process Automation opportunities?" B.S. thesis. University of Twente, 2021.

[31] Lukas-Valentin Herm, Christian Janiesch, Alexander Helm, Florian Imgrund, Kevin Fuchs, Adrian Hofmann, and Axel Winkelmann. "A consolidated framework for implementing robotic process automation projects". In: *International Conference on Business Process Management*. Springer. 2020, pp. 471–488.

[32] Alan Hevner, Salvatore March, Jinsoo Park, and Sudha Ram. "Design science in information systems research". In: *MIS quarterly* (2004), pp. 75–105.

[33] Integrify. *Robotic Process Automation (RPA) and Integrify*. 2021. URL: `https://www.integrify.com/robotic-process-automation-rpa-and-integrify/` (visited on 03/30/2022).

[34] Integrify. *Task Automation — Automate Repetitive Work*. 2021. URL: `https://www.integrify.com/task-automation/` (visited on 03/30/2022).

[35] Andres Jimenez-Ramirez, Hajo Reijers, Irene Barba, and Carmelo Del Valle. "A method to improve the early stages of the robotic process automation lifecycle". In: *International Conference on Advanced Information Systems Engineering*. Springer. 2019, pp. 446–461.

[36] Chris Lamberton, Damiano Brigo, and Dave Hoy. "Impact of Robotics, RPA and AI on the insurance industry: challenges and opportunities". In: *Journal of Financial Perspectives* 4.1 (2017).

[37] Volodymyr Leno, Stanislav Deviatykh, Artem Polyvyanyy, Marcello La Rosa, Marlon Dumas, and Fabrizio Maria Maggi. "Robidium: automated synthesis of robotic process automation scripts from UI logs". In: CEUR Workshop Proceedings. 2020.

[38] Volodymyr Leno, Artem Polyvyanyy, Marlon Dumas, Marcello La Rosa, and Fabrizio Maggi. “Robotic process mining: vision and challenges”. In: *Business & Information Systems Engineering* 63.3 (2021), pp. 301–314.

[39] Henrik Leopold, Han van der Aa, and Hajo Reijers. “Identifying candidate tasks for robotic process automation in textual process descriptions”. In: *Enterprise, business-process and information systems modeling*. Springer, 2018, pp. 67–81.

[40] Somayya Madakam, Rajesh Holmukhe, and Durgesh Kumar Jaiswal. “The future digital work force: robotic process automation (RPA)”. In: *JISTEM-Journal of Information Systems and Technology Management* 16 (2019).

[41] Christian Matt, Thomas Hess, and Alexander Benlian. “Digital transformation strategies”. In: *Business & information systems engineering* 57.5 (2015), pp. 339–343.

[42] Ken Peffers, Tuure Tuunanen, Marcus Rothenberger, and Samir Chatterjee. “A design science research methodology for information systems research”. In: *Journal of management information systems* 24.3 (2007), pp. 45–77.

[43] James L Price. “The study of organizational effectiveness”. In: *The sociological quarterly* 13.1 (1972), pp. 3–15.

[44] Nina Rizun, Aleksandra Revina, and Vera Meister. “Analyzing content of tasks in Business Process Management. Blending task execution and organization perspectives”. In: *Computers in Industry* 130 (2021), p. 103463.

[45] Frances Ryan, Michael Coughlan, and Patricia Cronin. “Interviewing in qualitative research: The one-to-one interview”. In: *International Journal of Therapy and Rehabilitation* 16.6 (2009), pp. 309–314.

[46] Nadine Sarter and David Woods. “Pilot interaction with cockpit automation: Operational experiences with the flight management system”. In: *The International Journal of Aviation Psychology* 2.4 (1992), pp. 303–321.

[47] Howard Schulman. *Know the Difference Between Workflow Automation and Robotic Process Automation*. 2021. URL: `https://www.lightico.com/blog/difference-between-workflow-automation-robotic-process-automation/` (visited on 03/30/2022).

[48] Shawn Seasongood. “A case for robotics in accounting and finance”. In: *Financial Executive* (2016).

[49] Nourhan Shafik Salah Elsayed and Gamal Kassem. “Assessing Process Suitability for Robotic Process Automation: A Process Mining Approach”. In: (2022).

[50] Gurún Lilja Sigurardóttir. “Robotic process automation: dynamic roadmap for successful implementation”. PhD thesis. 2018.

[51] Rehan Syed, Suriadi Suriadi, Michael Adams, Wasana Bandara, Sander Leemans, Chun Ouyang, Arthur ter Hofstede, Inge van de Weerd, Moe Thandar Wynn, and Hajo Reijers. "Robotic process automation: contemporary themes and challenges". In: *Computers in Industry* 115 (2020), p. 103162.

[52] Johannes Viehhauser and Maria Doerr. "Digging for Gold in RPA Projects–A Quantifiable Method to Identify and Prioritize Suitable RPA Process Candidates". In: *International Conference on Advanced Information Systems Engineering*. Springer. 2021, pp. 313–327.

[53] Jane Webster and Richard Watson. "Analyzing the past to prepare for the future: Writing a literature review". In: *MIS quarterly* (2002), pp. xiii–xxiii.

[54] Claes Wohlin. "Guidelines for snowballing in systematic literature studies and a replication in software engineering". In: *Proceedings of the 18th international conference on evaluation and assessment in software engineering*. 2014, pp. 1–10.

[55] Peter Wright and Andrew Monk. "The use of think-aloud evaluation methods in design". In: *ACM SIGCHI Bulletin* 23.1 (1991), pp. 55–57.

[56] Ali Yazici, Alok Mishra, and Paul Kontogiorgis. "IT service management (ITSM) education and research: Global view". In: *International Journal of Engineering Education* 31.4 (2015), pp. 1071–1080.

[57] Dirk Zimmermann and Lennart Grötzbach. "A requirement engineering approach to user centered design". In: *International Conference on Human-Computer Interaction*. Springer. 2007, pp. 360–369.

Appendix A

Consent Form Interview

Bedankt dat ik je binnenkort mag interviewen voor mijn scriptieonderzoek.

Dit interview, waarbij ik dieper in zal gaan op de huidige processen van de Centrale Service Desk, is onderdeel van mijn Masterscriptie.

De informatie die uit het interview zal komen hoop ik te kunnen gebruiken in mijn scriptie. Daarom is het van belang dat het interview opgenomen wordt en achteraf getranscribeerd wordt. Met de data zal vertrouwelijk worden om gegaan en persoonlijke informatie wordt geanonimiseerd en niet gedeeld buiten de betrokken personen in het onderzoek.

Uiteraard gebeurt dit niet zonder jouw toestemming, vandaar dat het van belang is dat dit document ondertekend is voordat het interview zal plaats vinden.

Met de handtekening hieronder geef ik aan dat:

- ik vrijwillig meedoe aan dit interview en snap waarom dit interview uitgevoerd wordt.
- ik er mee instem dat het interview opgenomen en getranscribeerd wordt.
- ik begrijp dat persoonlijke informatie over mij waarmee ik identificeerbaar ben, geanonimiseerd wordt en niet in het onderzoek terecht zal komen
- ik begrijp dat de informatie die ik geef over de processen gebruikt zullen worden om aanbevelingen te doen

Figure A.1: Dutch consent form that had to be signed by the interviewees.

Appendix B

Questions of the Interviews During Demonstration Preparation Phase

B.1 Introduction

Topic	Motivation
Introduction of the interviewee	This is added to have some more background information of the interviewee.
Introduction of the researcher	This is added so the interviewee knows more of the researcher as well.
Introduction of the purpose of interview	No new information is given here, as all interviewees already received information about the interview in advance per email.
Explanation scope and type of process	To increase the chance of getting a useful output, it is important to share the scope of the research and my definition of a process.

B.2 Process Questions

B.3 Closing

Question	Motivation
What is an example of a process that fits within the description?	This question provokes the interviewee to start telling about a new process.
How does this process start?	To understand the process, it is important to know if the process is manually started or triggered by another task.
What are the different steps of the process?	This questions helps to thoroughly understand the process.
Are these steps always the same?	This question is important because if the steps differ from time to time, the process is not a candidate for automation.
Which applications are involved?	With the answer of this question the consideration can be made if RPA is the right form of automation.
Which person is executing the process?	To understand the context of the process, it is good to know who is executing the process.
How often is this executed?	Only frequent processes are worth automating.
Is there an improvement going on with this process?	If someone within ProRail is already improving the process, then applying RPA is of no use now as it is not known how the future process will look like.
Is this process improved before?	Based on previous improvements and their results, a better estimate can be made.

Topic	Motivation
Thanking the interviewee	Being polite is important, as the time of someone else is valuable.
Ask for other interesting interviewees	Besides asking for general, interesting employees from ProRail to interview, there is also asked for process experts to further discuss the processes with.

Appendix C

Processes Collected During the Interviews

Table C.1: The processes collected during the interviews. #P stands for the number of participant of the interview, corresponding to the participant number in Table 6.1.

#	#P	**Process Description**	**Already happening?**
1	1	The manual searching for the right incident handling scenario for the different incidents.	✓
2	1	The manual searching in the handling scenario for the right actions to take for the specific incidents and events.	✓
3	1	Adding changes to the Marval ticket of an incident when a change is happening or done and the change(s) and incident are related.	✓
4	2	Execute the (first) steps of the event handling scenario when an event is happening.	X
5	2	Search for broken components when certain event or incident happens and mark the similarity between the component and the event/incident.	X
6	2	Mark the components that are involved with a certain change, so if the component goes down it can be related to the change.	X
7	2	Keep an eye on the trends in the Splunk data.	Attempt to
8	2	Add (the contact details of) the second/third party to the Marval ticket.	X
9	2	Push a possible disturbance to the right party instead of the CSD first.	X
10	3	Identify trends in Splunk data.	Attempt to
11	4	Manually adding personal details for an access request for people related to a change when a change has been approved.	✓
12	4	Send e-mail to change applicant when the change has not yet been executed, but the change is prepared and the end time has arrived.	✓
13	4	Send e-mail to OS (Operations Support) when a change has not yet been executed, but the change is prepared and the end time has arrived.	✓
14	4	Combine OBM notifications (related to number 2 of 2).	Attempt to
15	4	When having a priority 1 incident, sending a SMS to related people.	✓
16	4	Creating a Marval ticket and solving the incident after receiving a NCSC notification by e-mail .	✓

Appendix D

All Criteria

Table D.1: All the criteria that appear in the four analyzed methods.

Criterion	**Source**
Digital and Structured data	1
Few exceptions	1
Repetitive	1
Rules based	1
Stable process and environment	1
Easy data access	1
Multiple systems	1
Digital trigger	1
Standardized process	1
Redeployable personnel	1
Human error prone	2
High frequency	2
Time sensitive	2
Human productivity	2
Cost reduction	2
Irregular labor	2
Rule based	2
Low variations	2
Structured readable input	2
Mature	2
Frequency	3
Periodicity	3
Duration	3
Low Process Complexity	4
High Standardization Level	4
Rule-Based	4
Structured digital data	4
Repetitive/Routine	4
High volume / Frequency	4
Low automation rate	4
Low exception handling	4
High number of FTE's	4
High execution time	4

Appendix E

Sketch of the PLOST Framework

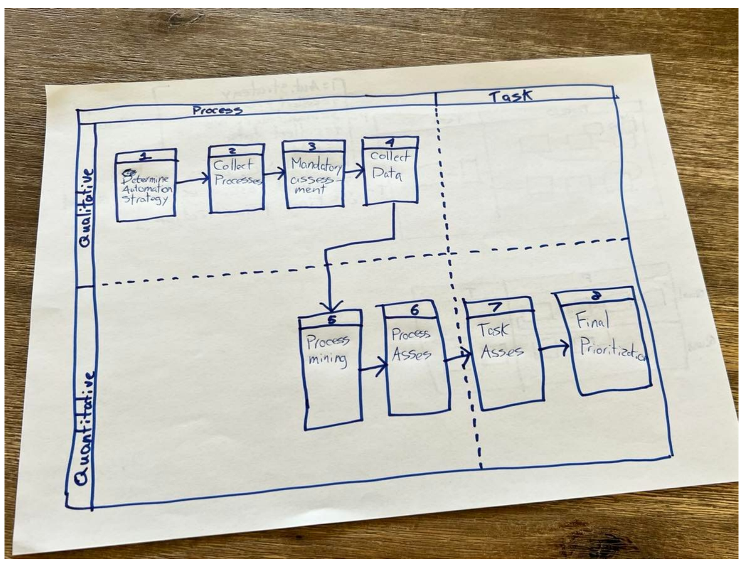


Figure E.1: Sketch of the PLOST Framework, made in the designing phase.

Appendix F

Consent Form Thinking-Aloud Experiments

Fijn dat je mee wil werken aan het Thinking-Aloud experiment voor mijn scriptieonderzoek.

Dit experiment, waarbij ik jou mijn methode deels laat uitvoeren, is onderdeel van mijn Masterscriptie.

De informatie die uit het expert zal komen hoop ik te kunnen gebruiken in mijn scriptie. Daarom is het van belang dat het interview opgenomen wordt en achteraf getranscribeerd wordt. Met de data zal vertrouwelijk worden om gegaan en persoonlijke informatie wordt geanonimiseerd en niet gedeeld buiten de betrokken personen in het onderzoek.

Uiteraard gebeurt dit niet zonder jouw toestemming, vandaar dat het van belang is dat dit document ondertekend is voordat het interview zal plaats vinden.

Met de handtekening hieronder geef ik aan dat:

- ik vrijwillig meedoe aan dit experiment en snap waarom dit experiment uitgevoerd wordt.
- ik er mee instem dat het experiment opgenomen en getranscribeerd wordt.
- ik begrijp dat persoonlijke informatie over mij waarmee ik identificeerbaar ben, geanonimiseerd wordt en niet in het onderzoek terecht zal komen

Figure F.1: Dutch consent form that had to be signed by the participants of the thinking-aloud experiment before participating.

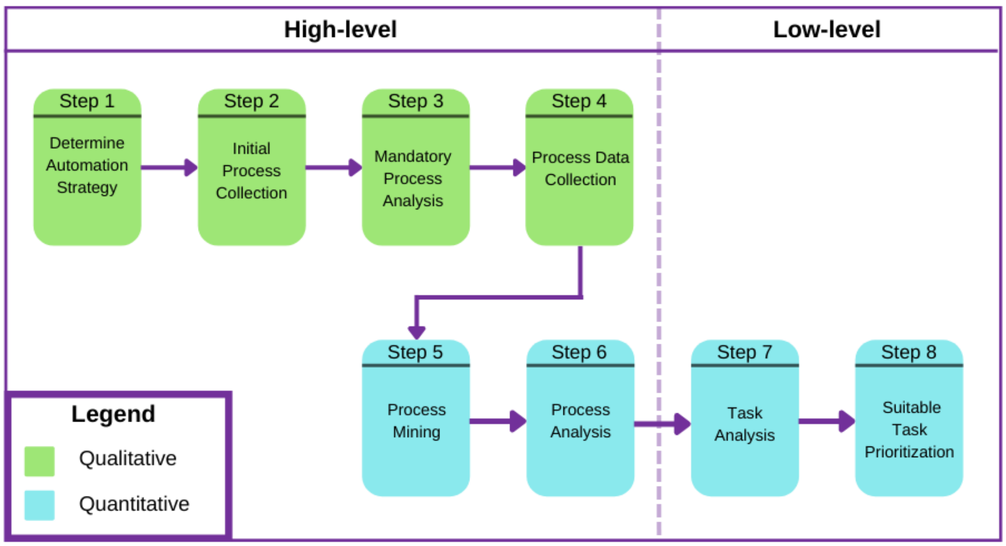
Appendix G

Tutorial Thinking-Aloud Experiments

Tutorial PLOST Framework

Introduction

You are going to execute the PLOST Framework, in which you will obtain a Prioritized List Of Suitable Tasks (PLOST) for RPA (Robotic Process Automation). The Framework consists of 8 steps. You can see them below.



You are going to execute every step in chronological order, so starting at step 1 and finishing at step 8. The focus of the execution is on the usability and repeatability of the framework and not on the data. This means every experiment will use the same dataset.

The goal is to identify tasks within processes that could be automated with RPA. If you're not familiar with RPA, it is advised to watch this short video before starting.
You received the following documents:

- *Tutorial PLOST Framework.pdf* -> This tutorial.
- *Method_Templates .xlsx* -> A file where you can fill in the information from the different steps.

Context

The context in which you will search for these tasks is the Central Service Desk (CSD) of ProRail, the company that manages the Dutch railway network. The core business of the CSD is solving ICT-related incidents and events. In 2021, there were 25135 incidents at the CSD. Their desk is 24/7 occupied with employees that all have the same skills. Their main ITSM tool is the Marval Service Management System , in which they keep track of all the open and closed incidents and events with the use of tickets.

Thinking-Aloud Experiment

Because this is a thinking-aloud experiment, you are asked to say everything that pops up in your head. There are no weird comments and if you have questions you can always ask them

to me. The written text in the tutorial can be read in your head, but please tell me what you are going to read. So for example “I start reading the description of step 3”. At the end of each step, you are asked to answer a couple of questions. Please read these questions aloud and also answer them speaking aloud.
Let’s start!

Step 1 – Determine the Automation Strategy

The desired outcome of a RPA implementation differs per organization and situation. Therefore, the automation strategy is determined at the beginning of the framework. This consists of two parts:

- The Business Value Prioritization
- Risk Level Assessment

Business Value Prioritization

For the business value prioritization, each stakeholder has to divide 100 points over three different business values. With prioritizing these values, you indicate what is the most important value to you to gain benefits. The business values are:

- **Time Savings:** By automating processes that are performed often or take a lot of time, great value can be found in the time saved. Besides that, bottlenecks in the processes can be automated, which raises the total throughput time of the process.
- **Quality & Accuracy Improvement:** Where humans work, mistakes are made. When automating tasks, the error rate can be minimized resulting in less rework and rejections, and removing delays because of these.
- **Availability & Flexibity Increase:** While humans work most of the time eight hours a day, RPA robots are available 24/7. Besides that, when the demand of a certain task is higher, a RPA bot can simply be copied while a new employee has to be on boarded. This makes it easier to scale up and down when a task is automated.

Open *Method_Templates .xlsx* and go to *Step 1*. You see that six different stakeholders already filled in the prioritization. Add yours in the column of S7.

Risk Level Assessment

With the assessment of the risk level, the organization indicates how much risk they are willing to take. The three risk levels are the following:

Risk Level	Process Description
High	**High** importance & **High** complexity
Medium	**High** importance & **Low** complexity OR **Low** importance & **High** complexity
Low	**Low** importance & **Low** complexity

The organization has chosen for a low risk level.

Step Questions

- On a scale of 1 to 10, how executable (uitvoerbaar) was this step?

Step 2 – Initial Process Collection

In this step, interviews were conducted at ProRail to collect processes. For practical reasons, the processes are already collected for you. You can find them in *Step 2* in *Method_Templates .xlsx*. It is not necessary to fully understand the processes.

Step 3 – Mandatory Process Analysis

This step takes as input the processes from the previous step and asses them based on six qualitative criteria. These criteria are mandatory, meaning that a process should meet all of them to stay in the framework. If that is not the case, the process is removed from the selection.

The six criteria are:

- **Digital and Structured Input:** The data input for the RPA robot needs to be structured and digital.
- **Easy Data Access:** It should be easy to access the data needed in the process, to make the execution of the framework as fluent as possible.
- **Few Variations:** A process with multiple variations needs more time to be programmed, can have reduced performance and is more difficult to maintain. Therefore, the amount of variations should be minimal.
- **Repetitive:** The process should be repeated in the same way over and over.
- **Clear Rules:** The process exists of clear steps and decision points, of which it is possible to define them so they can be programmed by simple rules
- **Mature:** The process already exists some time, does not have any upcoming changes in the near future and is not prone to changes. If a process is not mature, the maintenance of the RPA robot will outweigh the benefits of the implementation

Go to *Step 3* in *Method_Templates .xlsx*. Because more process knowledge is needed than can be given now, the analysis is already filled in. Only the last cell needs to be filled. If a process meets all of the criteria, make the last cell green. If not, make the cell red.

Process mining is a time-consuming activity. By removing the irrelevant processes in this step, we save time later in the process by only focussing on the relevant processes.

Step questions

- On a scale of 1 to 10, how executable was this step?

- Are the criteria in this step sufficient? If not, what are you missing?

Step 4 – Process Data Collection

The processes with a green cell stayed in the process. This are process 5 and 6. From now on we will call them respectively the **SMS Prio 1 Process** and the **NCSC Process**. For these processes, the data is collected. This is done with help of Marval and Xtraction. Xtraction is IT business intelligence software made by Ivanti. ProRail uses Xtraction as the report tool for Marval, their ticket software.
With this process data, an event log for process mining is created.
If you're not familiar with process mining, watch this short video.

Step 5 – Process Mining

The event logs are uploaded in a process mining tool. We will use Celonis for this. For each process a different dashboard is made. The links for the two process dashboards are:

- SMS Prio 1 Process
- NCSC Process

Tip: it is recommended to first take a look at the different dashboards to see how the processes look like.

Step 6 – Process Analysis

The two processes are assessed against different quantitative criteria. The criteria are:

- **Cycle Time:** The average throughput time that is needed to go from the process start to the process end.
- **Case Frequency:** The total amount of occurrences of the process.
- **Activity Frequency:** The total amount of occurrences of the different activities in the process.
- **Standardization:** The total number of variants. A high standardization is a low number of variants.
- **Length:** The average length of the process.
- **Automation Rate:** The percentage of events performed by the system.
- **Human Error Prone:** The rework rate of the process, which is the amount of activities executed more than once during the execution of a process.

Go to *Step 6* in *Method_Templates .xlsx*. Fill in the table based on the data in the dashboards.

With this analysis it becomes clear what the importance and complexity of the two processes are. This analysis can then be aligned with the determined risk level from Step 1.

The risk level is low, which means the company wants to automate processes with a low importance and low complexity.

Go to *Step 6* in *Method_Templates .xlsx*. Compare for every criteria the two values. Give the lowest value a green color. Compare which process has the most colored cells. This process is in the next step further analysed to identify suitable tasks.

Step questions

- On a scale of 1 to 10, how executable was this step?
- Are the criteria in this step sufficient? If not, what are you missing?

Step 7 – Task Analysis

For the last process in the framework, we are going to analyse what the different tasks are and which one would be the most suitable to automate with RPA. This analysis will be done with six different quantitative criteria. These different criteria are:

- **Activity Frequency:** The total amount of occurrences of a task.
- **Case Frequency:** The number of unique cases in which this task appears.
- **Duration:** The average duration of the total number of executions of the task.
- **Automation Rate:** The percentage of occurrences performed by the system.
- **Human Error Prone:** The rework rate of the task, which is the amount of activities executed more than once during the execution of a process.
- **Irregular Labor:** (number of times activity is executed in period x)/(number of times activity is executed in period x-1)

Go to *Step 7* in *Method_Templates .xlsx*. Fill in the table based on the data in the task dashboard. Do not forget to click on the *task* tab in the left corner of the dashboard to see the task data.

Step questions

- On a scale of 1 to 10, how executable was this step?
- Are the criteria in this step sufficient? If not, what are you missing?

Step 8 – Suitable Task Prioritization

The final step is to prioritize the tasks based on the analysis of the previous step.

Go to Step *Step 8* in *Method_Templates .xlsx*. The first table shows the task analysis from *Step 7* and the second table the business value prioritization of S*tep 1*.

Rank for each criteria the tasks in the analysis in the second table. The highest value receives an 8, the second highest a 7, the third a 6 etc. If tasks have the same value, give them the same number.

Example:

se case.

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency	7	6	7	5	7	7	8	7
Case Frequency	8	7	8	6	8	8	8	8
Duration	5	3	6	7	4	2	8	2
Automation rate	7	8	8	8	6	8	8	5
Human Error Prone	6	8	6	6	6	6	7	6
Irregular Labor	6	8	6	6	6	6	7	6

Now it’s time for the final prioritization. This is done by multiplying the scores of the business value prioritization with the ranking. Each criterion matches with one of the three business values. You can see which criterion matches which business value in this table:

Criteria	Time Savings	Quality & Accuracy	Availability & Flexibility
Activity Frequency	√	√	√
Case Frequency	√	√	√
Duration	√	X	X
Automation Rate	√	√	√
Human Error Prone	X	√	X
Irregular Labor	X	X	√
Total	**4**	**4**	**4**

When a criterion matches more than one business value, the score of the highest business value is used for that criterion. For example: Case Frequency matches all three business values, but Quality and Accuracy Improvement has the highest score. Then the cells in the Case Frequency row will be multiplied with the score of Quality and Accuracy Improvement.

Copy the value of each business value behind the criteria in the second table, based on the distribution of the business values showed above. Now the final prioritization will automatically appear.

Tadaa! The task that has the the highest priority to be automated with RPA will be showed in the darkest green color! The dark red color is for the task with the least priority.

Step questions

- On a scale of 1 to 10, how executable was this step?
- What do you think of the amount of calculations in this step?

Questions

1. To what extent do you think the addition of process mining benefits the identification of RPA tasks? Give a number from 1 to 10.
2. How would you describe your overall experience with the framework?
3. What is your opinion about the duration of the framework?
4. What did you like the most about the framework?
5. What did you not like about the framework?
6. What was the easiest part of the framework?
7. And what was the hardest part?
8. If you could change anything to the framework, what would you change? And why?

Appendix H

Templates Thinking-Aloud Experiments

Step 1

Determine the Automation Strategy

Fill in

Business Value Prioritization

Business value	S1	S2	S3	S4	S5	S6	S7	Total
Time Savings	35	15	47	70	25	25		217
Quality & Accuracy Improvement	60	40	39	30	55	50		274
Availability & Flexibility Increase	5	45	14	0	20	25		109
Total	100	100	100	100	100	100	0	600

Total scores / 7

Score
31,00
39,14
15,57
100,00

Automation Strategy

Business value	Score
Time Savings	31,00
Quality & Accuracy Improvement	39,14
Availability & Flexibility Increase	15,57
Risk level	Low

Step 2

Initial Process Collection

Process	Description
1	The manual searching for the right incident handling scenario for the different incidents.
2	Adding changes to the Marval ticket of an incident when a change is happening or done and the change(s) and incident are related.
3	Manually adding personal details for an access request for people related to a change when a change has been approved.
4	Send e-mail to OS (Operations Support) when a change has not yet been executed, but the change is prepared and the end time has arrived.
5	When having a priority 1 incident, sending a SMS via a web form to related people.
6	Creating a Marval ticket and solving the incident after receiving a NCSC notification by e-mail.

Step 3

Mandatory Process Analysis

Criteria	P1	P2	P3	P4	P5	P6
Digital and structured input	✓	X	✓	X	✓	✓
Easy data access	X	X	X	✓	✓	✓
Few variations	X	X	✓	X	✓	✓
Repetitive	✓	✓	✓	✓	✓	✓
Rules Based	✓	✓	✓	X	✓	✓
Mature	✓	✓	✓	✓	✓	✓
Stay in framework						

Assess whether the processes stay

Make use of:

Color	Description
	Meets all criteria
	Does not meet all criteria

Step 4

Process Data Collection

Data collected for:

Process	Name
Process 5	SMS Prio 1 Process
Process 6	NCSC Process

Step 5

Process Mining

Dashboards created in Celonis for:

Dashboard SMS Prio 1 Process	Click
Dashboard NCSC Process	Click

Step 6

Process Analysis

Criteria	SMS Prio 1 Process	NCSC Process	
Cycle Time			In hours
Case Frequency			Per year
Activity Frequency			Per year
Standardization			
Length			
Automation Rate			
Human Error Prone			

Fill in with dashboard data

Criteria	Description
Cycle Time	Average throughput time in hours.
Case Frequency	Total number of occurrences of the process.
Activity Frequency	Total number of occurences of the different events in the process.
Standardization	Total number of variants.
Length	Average number of events per case
Automation Rate	Percentage of events performed by the system.
Human Error Prone	Rework rate

Step 7

Task Analysis

Link to dashboard

Use this order for the tasks (same as in dashboard):

T1. Behandeling T2. Functieherstel T3. Geregistreerd T4. Gesloten

T5. Heropen T6. Opgelost T7. Opgelost KA klant geïnformeerd T8. W

Values

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency								
Case Frequency								
Duration								
Automation Rate								
Human Error Prone								
Irregular Labor								

Colors will appear. The reason for this will be made clear in the nex

Criteria	Description
Activity Frequency	The total amount of occurrences of a task.
Case Frequency	The number of unique cases in which this task appears.
Duration	The average duration of the total number of executions of the task.
Standardization	Total number of variants.
Automation Rate	The percentage of occurrences performed by the system.
Human Error Prone	Rework rate of the task.
Irregular Labor	Irregular work ratio.

Step 8

Suitable Task Prioritization

T1. Behandeling T2. Functieherstel T3. Geregistreerd T4. Gesloten
T5. Heropen T6. Opgelost T7. Opgelost KA klant geïnformeerd T8. Wacht

Task analysis (automatically copied from Step 1)

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Case Frequency	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Duration	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Automation Rate	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Human Error Prone	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Irregular Labor	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Business value prioritization (automatically copied from Step 1)

Business value	Score
Time Savings	31,00
Quality & Accuracy Improvement	39,14
Availability & Flexibility Increase	15,57

Ranking

Criteria	T1	T2	T3	T4	T5	T6	T7	T8	BV Score
Activity Frequency									0
Case Frequency									0
Duration									0
Automation Rate									0
Human Error Prone									0
Irregular Labor									0

Prioritization

Criteria	T1	T2	T3	T4	T5	T6	T7	T8
Activity Frequency	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Case Frequency	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Duration	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Automation Rate	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Human Error Prone	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Irregular Labor	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00