Universiteit Leiden

ICT in Business and the Public Sector

An assessment model for RPA process suitability and business goal contribution

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Date: 23/08/2021

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MASTER'S THESIS

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Abstract

The fast growth of the Robotic Process Automation (RPA) sector shows that businesses are interested in this form of lightweight automation. Whilst RPA can provide businesses with a relatively cheap automatization option and can provide major benefits, downsides to this immense popularity of RPA arises. With more businesses implementing RPA, studies show that 30-50% of all RPA projects fail due to multiple pitfalls during the RPA implementation. Many studies point out that the number one pitfall during these implementation projects is the assessment of processes on RPA suitability. A wrong process assessment can result a failed RPA implementation, disappointing implementation results, higher costs and longer implementation times.

There are currently process assessment models for RPA. However, these are often to narrowly focused. This creates the need for an assessment model that consists of a complete set of criteria for both RPA process suitability, as well as RPA contribution towards a company's business goals. To fill this gap, the aim of this study is to improve the RPA process selection by creating an assessment model that satisfies the need for process assessment on RPA suitability and business goals in order to let business choose the best processes for RPA implementation projects.

The assessment model is created using the Design Science methodology. Via a literature review, we reach understanding of the different criteria impacting RPA process assessment and gain knowledge on the relation between process mining and RPA. During the design phase of this thesis, we create measurements for each of the criteria, create a scoring mechanism for the assessment model, and develop a way to optionally improve the assessment with the help of process mining. Finally, the assessment model is validated using a case study in a real-life situation in order to validate its use in the problem context.

Based on the case study results and stakeholder feedback, this thesis shows that the created assessment model is able to assess process on their business goal and RPA suitability via the assessment on multiple criteria. Additionally, this thesis shows that the optional support of process mining during the assessment increases the accuracy of the model, whilst also decreasing the throughput time compared to a manual assessment. Closing the gap that is currently present in literature and providing practitioners with an assessment model that helps them to assess a process on RPA process suitability and business goal contribution.

Keywords: *RPA, Process Mining, Decision support, Automation, RPA suitability, Process assessment model*

Acknowledgements

The completion of this Master thesis would not have been possible without the support of many people. I am incredibly grateful for all the support and advice I got during this thesis. Whilst many people supported me, I would like to explicitly thank and mention the following few.

Firstly, I would like to thank my first supervisor Prof. dr. ing. Joost Visser. Even though this thesis has been written during the COVID-19 pandemic, he would always make sure that we could connect in some way and so provided continual guidance, feedback and advice. These frequent meetings and discussions helped me to move forwards every time. Similarly, I am very grateful to my second supervisor Drs. Pieter Kwantes and company supervisor Coen Zwep for their feedback and support on various versions of this thesis. I would also like to specifically thank the Service Desk team at Rexel Nederland for their support during this thesis case study.

Finally, I would like to thank my friends and family for their support and encouragement in times I needed it the most. Helping me to keep my focus and create moments of relaxation if necessary.

Damian Verbrugge
Zoetermeer, August 23rd, 2021

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List of Abbreviations

AI – Artificial Intelligence
BPM – Business Process Management
BPMN – Business Process Modelling Notation
CAGR – Compound Annual Growth Rate
DS – Design Science
EQ – Effect questions
ESI – Employee Satisfaction Index
FTE – Full Time Employee
KQ – Knowledge question
ML – Machine Learning
PCE – Process Cycle Efficiency
ROI – Return on Investment
RPA – Robotic Process Automation
RSQ – Requirement satisfaction questions
SQ – Sensitivity questions
TAT – Turnaround time
TQ – Trade-off questions
UI – User Interface

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1. Introduction

Robotic Process Automation (RPA) has increased its sector value over the past years. The sector has grown from $250 million in 2016 to an expected value as high as $13.74 billion by the end of 2028, with an expected compound annual growth rate (CAGR) of 32.8% from 2021 to 2028 [1], [2]. Besides the economic growth of the sector, the literature contribution is also increasing each year, showing great interest in and relevance of RPA in literature [3]. Figure 1 shows the number of publications in the field of RPA increasing each year. Still, the amount of available papers is relatively small [3]–[5].

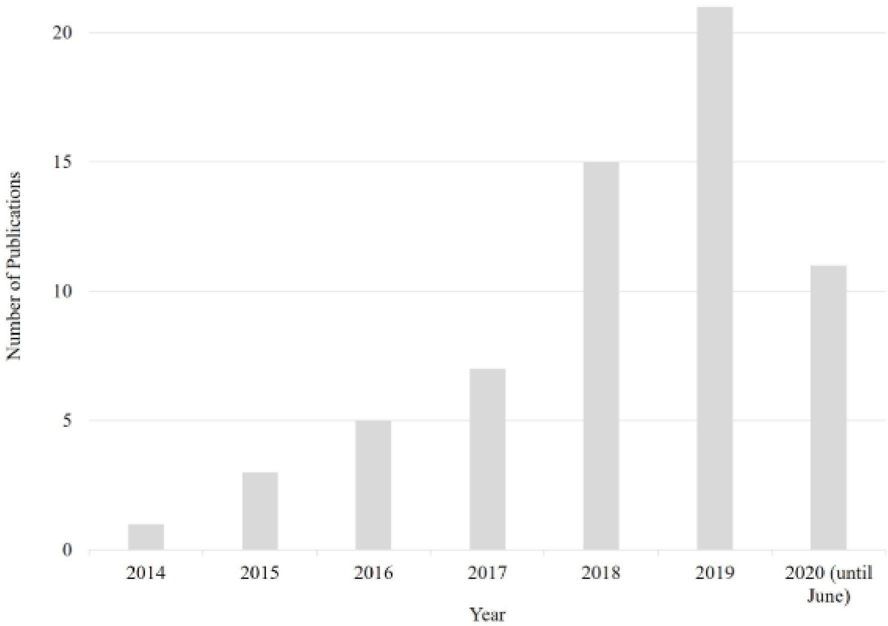


Figure 1 - Distribution of publications over the years

RPA is considered to be a form of "lightweight" IT [3], [6]–[13]. Compared to traditional automation, that is often embedded in software and databases, RPA rather lies on top of applications and operates via the user interface (UI). Due to its nature of being a process supportive application, driven by a combination of user and vendor ownership, RPA is more lightweight than general automation [14]. The term "robotic" might encourage thinking about RPA as robots that are wondering around doing certain tasks, but in reality a robot in RPA corresponds to a software program [15].

The aim of these robots is to tackle tasks and perform processes in a fast and more efficient manner than humans can do it [8], [15]–[17]. Multiple case studies described how RPA has benefitted their daily routines. With case studies reporting numbers up to 96% more efficiency on certain processes [18] the field of RPA shows its power. Most of the case studies show that the RPA implementation has benefited them on the reduction of errors in the process, throughput time, and cost due to FTE reduction [12], [16]–[18]. These proven benefits are often main drivers for businesses to start implementing RPA into their daily routines. Hence the increase in sector growth.

However, RPA implementation is not as straight forward as it might seem. As more businesses implement RPA and the sector grows, more data becomes available on the success rate of the RPA implementation projects. This reveals that 30-50% of all RPA projects fail.

According to multiple researches RPA is clearly no "one-size-fits-all" solution and often requires specific demands and analysis before it can be successfully implemented [19]–[21]. Even when the bots are correctly set-up, they still need to be managed, improved and updated in order to get the most out of them [6], [22]–[24]. R. Syed et. al. and Wewerka et. al. created papers that show there are risks and challenges throughout the RPA lifecycle that can influence the effectiveness of an RPA solution in practice and reveal why 30-50 percent of RPA projects fail [3], [6].

One of the main challenges when it comes to RPA projects is assessing the right processes in order to successfully implement RPA. Many researches pointed this out as the number one challenge in RPA projects and reason for failing RPA implementations [6], [11], [20], [25]–[27]. Wrong process assessment often results in unforeseen obstacles during the implementation and use of the RPA bots. These obstacles then result in higher cost, longer throughput time or even a complete stop of the project [9], [11], [21].

This is also the case for our supporting company – Rexel Nederland. Rexel a is business to business wholesaler of electrical supplies, active in twenty-five countries with over 24,000 employees and a 12.6 billion euro revenue in 2020 [28]. Rexel's core business is to provide customers with the supplies they need and add value through innovation, expertise, competitive pricing and flexibility.

The Dutch branch – Rexel Nederland – contributes to around 2.62% of this revenue (330 mil. Euro) coming from around 4600 customers that are being served from 21 local stores and 1 main distribution center with the help of 400 employees. Nationally, Rexel Nederland has a market share of 16.9% in 2020, making them the second largest player in the sector.

One of Rexel's main strategical pillars is based around the use and adoption of digital information and digital solutions. The main goal of this pillar is to improve the company and to become the benchmark for data use in the world of energy sector distribution [28]. RPA is one of the many digital solutions Rexel has embraced as part of their strategical plan, resulting in a global contract with one of the biggest RPA vendors currently in the field. The problems described in literature are also present at Rexel and Rexel Nederland.

At Rexel Nederland, a wrong process assessment led to a failed RPA implementation. Management at Rexel had the desire to improve processes that where not feasible for general automation but did take up a lot of FTE to perform. The goal of RPA implementation was to reduce the required amount FTE for the process and improve the quality of the process by reducing the errors. Because RPA is known for automating processes that might not be feasible for traditional automation [5], Rexel started to explore the possibilities of RPA implementation for these processes.

Before Rexel started the implementation, they assessed all RPA candidate processes using a combination of two criteria: frequency (the number of times the process was used in a day) and the number of exceptions to the standard process flow. This assessment method was proposed by the RPA technology vendor company. A process could be one of four categories: Quick Win, Strategic, Debatable, or Avoid. Where most of the time, only processes that are labeled as "avoid" would not be automated. This model is shown in Appendix 9.1 – RPA assessment by Rexel.

The result of this process assessment leads the management of Rexel believe that all processes where eligible for RPA implementation, since the assessment didn't mark any of the processes as "Avoid". During implementation however, some processes where not applicable for implementation and were stopped during the development stage. Often, this was because parts of the process where not completely digitalized and thus unsuited for RPA automation. A criteria the assessment method did not assess a process on and in this case lead to a complete stop of the RPA development.

From the processes that did pass the implementation phase, not all processes met the expectations of Rexel. Whilst some processes resulted in the reduction of required FTE and decrease of human errors, others failed to meet these expectations. In this case, the process had such high number of exceptions that the employees spend around the same amount of time on processing the RPA exceptions as on the old process before RPA implementation. Ninety percent of the assessed and approved processes either didn’t pass the development stage or are no longer in use because they didn’t contribute to the business goals as desired before the start of the implementation.

This shows that the problems raised in literature are present in practice and that a wrong process assessment for RPA can cause RPA implementation to fail or meet expectations. During the thesis, we will focus on solving the issues that are raised in literature and present in practice in order to prevent future RPA implementations from failing now that great sector growth is expected and more businesses will likely be implementing RPA in the near future.

1.1. Problem statement

Literature shows us that 30-50% of all RPA projects fail and that businesses are looking for a solution to better assess their processes on RPA potential [25]. Multiple studies support this by calling the process assessment one of the biggest challenges in RPA projects [3], [5], [9], [13], [17], [20], [26], [27]. Other research extend on this and describe the problem as a gap in literature and the necessity of a 'checklist' for RPA suitability is critical and often described as a major challenge [6], [11].

As stated earlier, RPA is no "one-size-fits-all" solution [19]–[21]. This is because every company in every sector operates differently using different processes, applications, and with different expectations. Rexel's aim was to reduce the amount of FTE and also increase process quality. Other use cases show RPA implementation goals like increasing customer satisfaction (Uber) [4] and increasing process transparency (Vodafone) [18].

Combining the literature gap and the translation of this gap to the supporting company, we can identify a gap between the ideal situation and the reality of RPA process assessment. In the ideal situation, companies looking to implement RPA can assess their processes on suitability, resulting in a list of processes that are suitable for RPA and generate the expected benefits the company is looking for.

In reality, this is not the case. Currently, companies are unable to successfully assess their processes on RPA suitability and are unable to identify in which processes RPA implementation will add the most value to their business goals. As shown by Rexel Nederland, where the RPA project failed due to a wrong process assessment, but also because the RPA implementation couldn't meet their expectations and support their business goals.

This issue is also addressed in multiple studies and mentioned multiple times in future work sections. Experts state that the current assessment models are to focused on certain benefits of RPA and lack understanding of the complete assessment picture. They state that RPA implementation can have a wide range of implementation motives which need to be addressed in an assessment model in order to perform a complete assessment [9], [10], [15], [20]. Wanner et. al. states: "*A process or tasks can be judged by its impact or importance to the business. This is where literature does not provide a clear outline"* [20].

Other case study outcomes also suggest the broadening of the assessment scope in future work chapters. They suggest to not only focus on the technical suitability of a process for RPA, but also include business impact and relevance [11], [13], [20], [29].

It is important to close this gap between the ideal situation and reality now that the RPA sector is growing rapidly, and more companies will be implementing RPA in the future. By closing this gap now, we aim to reduce the amount of failed RPA implementation due to insufficient process assessment in future implementations. Ultimately resulting in better adaptation of the RPA technology, less implementation cost for businesses and an overall better experience with RPA projects.

The gap can be translated to some main issues that are currently present in failing RPA projects and need to be solved:

- Literature does not support outlines to assess a process on business importance
- Businesses are unable to identify which processes are best suited for RPA implementation
- There is no complete "checklist" for RPA suitability

In literature, multiple studies have tried to solve one or more of these issues by creating a way to successfully assess a process on its RPA suitability. Each of the models are different due to the scope that has been chosen during the research, leaving room for further research. To the best of our knowledge, there is currently no research available that solves all of the mentioned gaps in one assessment model.

Wanner et. al. [20] created a model that assesses a process using a combination of short term criteria and process mining to select the best possible processes to implement RPA in with the goal of selecting the process with the best short term ROI. Neglecting other RPA implementation goals such as seen by Rexel, Vodafone and uber. Here, experts stated the importance of other business drivers when implementing RPA besides short-term ROI.

Wellmann et. al. [26] created a process assessment framework that assess a process on its RPA suitability using process mining insights, RPA criteria and different view-points. Whilst the list of criteria is extensive, there are no criteria available to assess a process on its contribution towards business goals after RPA implementation. There is also no way to quantify the measurement and thus measure to what extend the process is suitable for RPA, requiring great RPA and process knowledge to deem a process suitable or unsuitable.

Santos et. al. [11] researched a great amount of RPA suitability criteria and RPA business benefits based on a literature review. However, the research is limited towards creating a perspective of RPA and does not translate these criteria to a checklist/ assessment model.

Geyer-Klingeberg et. al. [18] researched how the assessment of processes for RPA can be improved by the use of process mining. Here, process mining showed great benefits for the assessment of the process on frequency and standardization. The assessor could now use real life data to base hit assessment upon. Like Wanner et. al. [20], it was important to select the right processes, otherwise process mining would not be useful for the RPA implementation.

Currently, no assessment model provides businesses with the option to not only assess a process on its RPA suitability, but also help businesses assess on the RPA benefits towards their business goals. The available literature provides insights on these topics, but there is no model that combines this available information into one to help solve the current gap in literature. Some are to narrowly focused, making them unable to be applicable in all situations, where others provide a great amount of information, but fail to create an assessment model for businesses to benefit from this knowledge.

The combination of process mining and RPA assessment seems to be promising and could improve the assessment as mentioned in multiple papers. It is important to pick the right processes, otherwise process mining cannot be used for the assessment.

This thesis aims to create an assessment model that can assess a process on its RPA suitability and identify in which processes RPA implementation will contribute most towards the business goals. Due to the amount of future work mentions in the current literature and the shown benefits whilst assessing a process, the thesis will also research how to incorporate process mining to improve the assessment.

This will be done via the Design Science method, where an artifact will be created based on a combination of literature review insights and a design cycle. By combining these two, the available literature will be used to create a model that can fill the gap in literature and provide businesses with a complete assessment model for RPA suitability. The created model will be validated in practice using a case study at our supporting company, Rexel Nederland.

1.2. Research scope

An RPA implementation starts with the identification of a business problem or strategic goal. This then needs to be solved or achieved with the help of RPA, resulting in an RPA implementation project. To successfully guide this RPA implementation, Sigurðardóttir et. al. [9] provided an RPA implementation roadmap. This research will not focus on the complete RPA implementation roadmap, but rather on the process selection that takes place as part of the implementation process.

Prior to the assessment of processes, the implementation goals are determined and supported on a management level and processes for assessment are identified. The implementation goals and the list of RPA candidate processes serve as input and starting point of this thesis scope – the assessment of selected RPA candidate processes.

During the process assessment of RPA, Sigurðardóttir et. al. [9] advises to use a combination of key stakeholders:

Management
During the assessment, it is important to have the management's attention. The management has determined the RPA implementation goal and will need to make sure that the assessment suits this goal. It is also up to the management to ultimately determine what processes are suited for automation and will be implemented based on a combination of the goals and the outcome of the assessment.

Process owner
A process owner's main tasks are to plan, control and govern a process [30]. For RPA assessment, the process owner of the RPA candidate processes – selected in the step prior to the assessment – is the most important stakeholder. The process owner has the most knowledge about a process and can therefore provide most of the information that is required to fulfill the assessment.

IT-support
Because RPA is a technical solution that needs to be supported by IT, it is best to involve a technical stakeholder for the process assessment. If the assessment involves the gathering and analyzing of data, it is often best to incorporate an IT stakeholder that can provide and analyze the data. Also, the IT stakeholder can provide valuable information about the RPA implementation from a technical perspective [9].

The outcome of the assessment should provide the management with enough information about all candidate processes to determine whether a process is suitable for RPA implementation and contributes to the implementation goals to select the processes that will continue to the next phase.

For the scope of this research, any activities prior to the assessment are deemed out of scope. The assessment model must be able to work with these prior steps and support the available information. Any steps after the process assessment are also deemed out of scope. The assessment model will be created in such a way that it will support the stakeholder goals and can serve as an input for the RPA implementation steps after assessment. The assessment model will be created with the stakeholders use in mind as described above.

The validation of the model will also be limited to Rexel Nederland only. Due to time restrictions, we are not able to test the model in different companies or sectors. We will however not limit the use case of the model to Rexel only and will only use Rexel Nederland as a validation company. The model will, like the implementation roadmap of Sigurðardóttir et. al. [9] be applicable in all countries, companies, and sectors.

1.3. Research questions and goals

The problem statement found that businesses are unable to assess their processes on RPA suitability and business goal contribution. The current models are often to narrow focused and therefore not applicable in all situations. This thesis aims to solve this by answering the following research question:

“How can you assess a process on its RPA suitability, whilst also taking business goals into account?”

During the thesis, design science will be used as research methodology. Because of this, we transformed the research question to a technical research question – better known as a design problem. This requires the use of a standard template, creating the following technical research question:

Improve the RPA process selection by creating an assessment model that satisfies the need for process assessment on RPA suitability and business goal contribution in order to let business choose the best processes for RPA implementation projects.

The goals of this thesis will be:

Goal 1 – Design an assessment model that can score processes on RPA suitability and business goal contribution.
Goal 2 – Ensure the assessment model can be used in most businesses, sectors, and scenario’s
Goal 3 – Have optional process mining support for the assessment
Goal 4 – Validate the model in a real-life test case

1.4. Structure of the thesis

Chapter 1 – The introduction to the thesis, problem statement, approach and research questions

Chapter 2 – The research methodology that will be used during the thesis.

Chapter 3 – The literature review will focus on providing a theoretical foundation for the creation of an artifact. Here, we focus on answering knowledge questions on RPA criteria, process mining and measurement options that will later be used to design the actual assessment model.

Chapter 4 – The design phase of the design cycle. In this chapter we will be designing an artifact based on the theoretical foundation described in chapter 3. Here we build on the foundation to create an artifact that meets the requirements and fill the current gap in literature.

Chapter 5 – The validation of the artifact in its problem context is described in this chapter. Here, the artifact will be validated using a real-life use case at Rexel. By answering validation questions, we validate if the model meets its requirements in a real-life problem context.

Chapter 6 – The discussion chapter will be used to state interpretations, suggestions and declare our opinions.

Chapter 7 – The conclusion of the paper including the answer to the research question, limitations of the study and future work suggestions.

2. Research Methodology

This chapter will explain the chosen research methodology for this thesis. It includes how Design Science will be used during the thesis, how the literature review will be conducted and elaborate on the design cycle stages.

2.1. Design Science

For this thesis, a qualitative research methodology is used to research the problem statement and create a possible solution. The chosen methodology for this is design science as described by Roel J. Wieringa in “Design Science Methodology for information systems and software engineering” [31].

Design science is the design and investigation of artifacts in context. These artifacts will interact with the problem context in order to improve this context [31]. Design Science consists of two main parts, the design and investigation. These correspond to two kinds of research questions, namely, design problems and knowledge problems. Figure 2 shows the differences between these questions.

Design problems	Knowledge questions
Call for a change of the world	Ask for knowledge about the world
Solution is a design	Answer is a proposition
Many solutions	One answer
Evaluated by utility	Evaluated by truth
Utility depends on stakeholder goals	Truth does not depend on stakeholder goals

Figure 2 - Heuristics to distinguish design problems from knowledge problems

Based on the type of problem, a cycle will be chosen to find a solution to this problem. With Design Science, each type of problem will have its own cycle that supports the design process and give guidelines on how to improve the problem context using a newly developed artifact.

Every cycle will follow the framework for Design Science as proposed by Wieringa et. al. [31] – Figure 3. This framework is similar to an also widely used framework of Hevner et al. [32]. However, we found that the model of Wieringa et. al. is more extensive and can provide us with more information about the use of design science in research.

The framework of Wieringa et. al. shows the different types of interactions between the research methodology and the research context. Here, there are three main interactions: between design science and the social context, between design science and the knowledge context, and within design science between the design and investigation.

The interaction with the social context – also referred to as the relevance cycle by Hevner et al. [32] – aims to retrieve important stakeholder information and goals about the research. The final artifact will be released into the social context as a result of the research and answer to the stakeholder’s information, goals and questions. The results of this social context interaction are described in the first chapters of this thesis, where the objectives, research questions, scope and problem statement are explained.

The interaction between the knowledge context and design science – also known as the rigor cycle in Hevner et al. [32] – is mainly focused on solving problems and answering questions about the artifact. Here, the knowledge context consists of existing theories and designs that can be helpful for the research. In this thesis we will also interact with the knowledge questions in the literature review, where we will build the base for our artifact and find solutions to design problems.

The final interaction within design science is based on solving the two types of problems as explained in figure 2. Here we will create an artifact based on the needs of the social context and the answers to our problem questions solved by the interaction with the knowledge context. This part of design science often iterates between solving design problems and answering knowledge questions. This thesis will also be based around this principle, where design problems and knowledge questions will be iterated to create the final artifact.

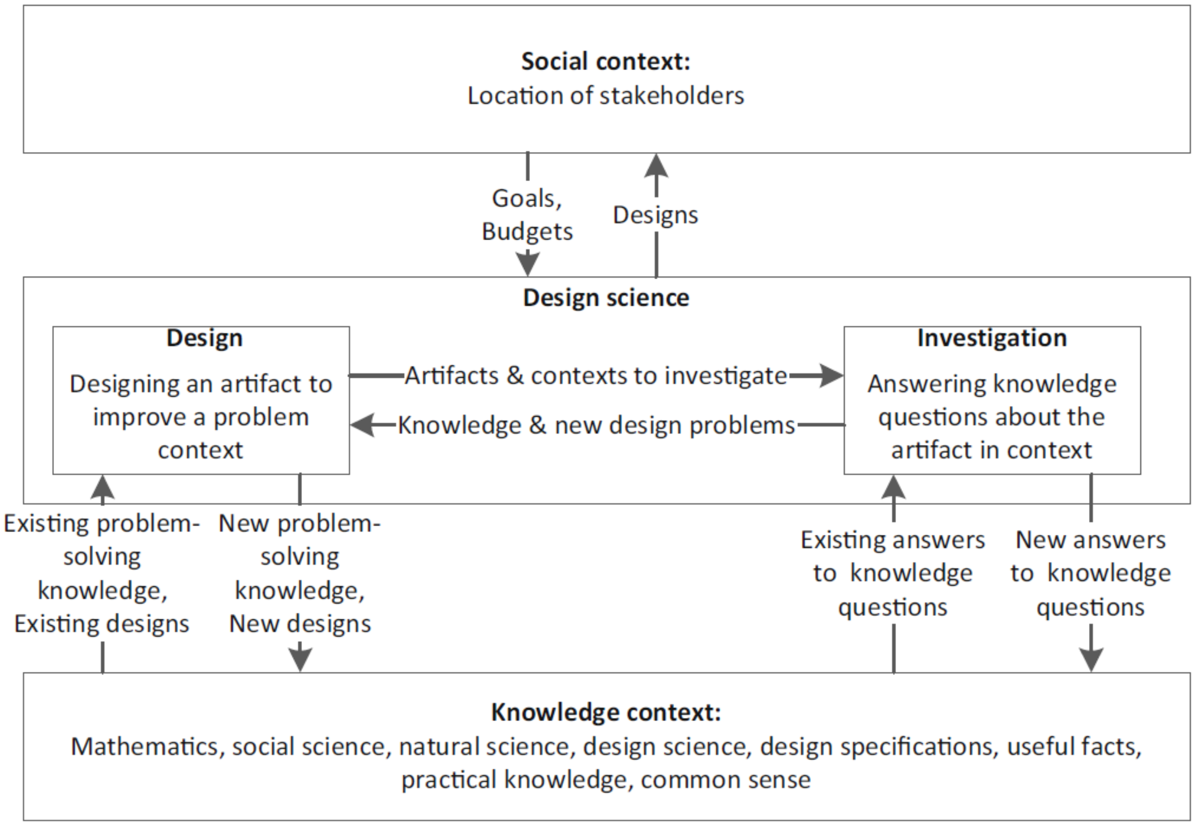


Figure 3 - A framework for Design Science

Finally, when an artifact is ready, the artifact will be validated or evaluated. Here, the main difference is that a validation will be done theoretically e.g., testing the artifact in "laboratory-created" scenarios and an evaluation will be done in the actual problem context itself – the real world. After this, a researcher might be satisfied with the results or decide to perform another cycle. This thesis will be limited to one design cycle with an evaluation in the problem context via a use case at Rexel Nederland.

2.1.1. Design cycle

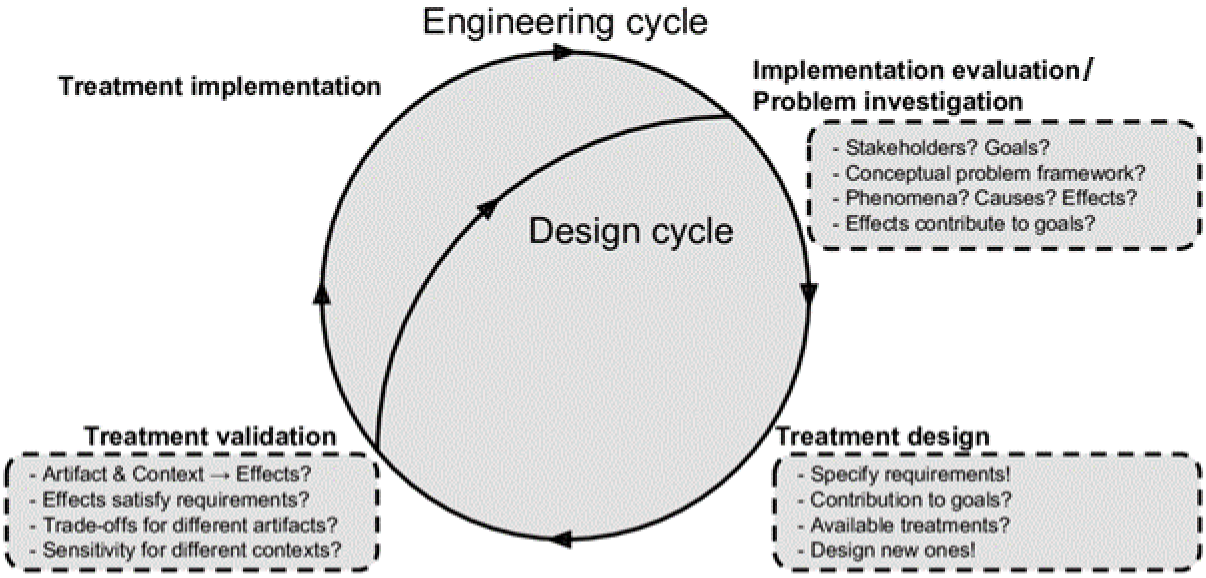


Figure 4 - The design cycle

The design cycle is used to solve design problems and create an artifact for them. The cycle iterates between design and investigation whilst connecting with the surrounding contexts. The design cycle consists of three main tasks, namely, problem investigation, treatment design and treatment validation [31]. Since our main research question has been defined as a design problem, we will use the design cycle to create an artifact that will solve this design problem. We will not be implementing the treatment in the scope of this thesis and will thus not perform the full engineering cycle.

Problem investigation

The problem investigation is about researching the problem before an artifact is designed. In this phase we will investigate and describe the problem without the design of an artifact. These activities have been conducted and are described in the introduction chapter of this thesis. For this, we investigated the problem statement in its problem context and in literature. From here we created our research question found in chapter 1.3. This has formed the base of the thesis and the design cycle.

Treatment design

In this phase of the design cycle, requirements must be specified for the artifact. These requirements are treatment goals and will form the base of the artifact. As shown by figure 5, the artifact must contribute towards the research goal. Solving requirements with the artifact will help create an artifact that fulfills the research goal and so improve the design problem. Our requirements can be found in chapter 2.3.

From here, we use the interaction with the knowledge context to find available treatments to our knowledge and design problems. We will do this via literature review, described in chapter 3. The literature review will help us answer the problems and give us a base to form the artifact. The design of this artifact will thus be based on the answers to our knowledge questions embedded in the literature review findings so that we can create an artifact that interacts with the problem context with the goal of solving our design proproblem.

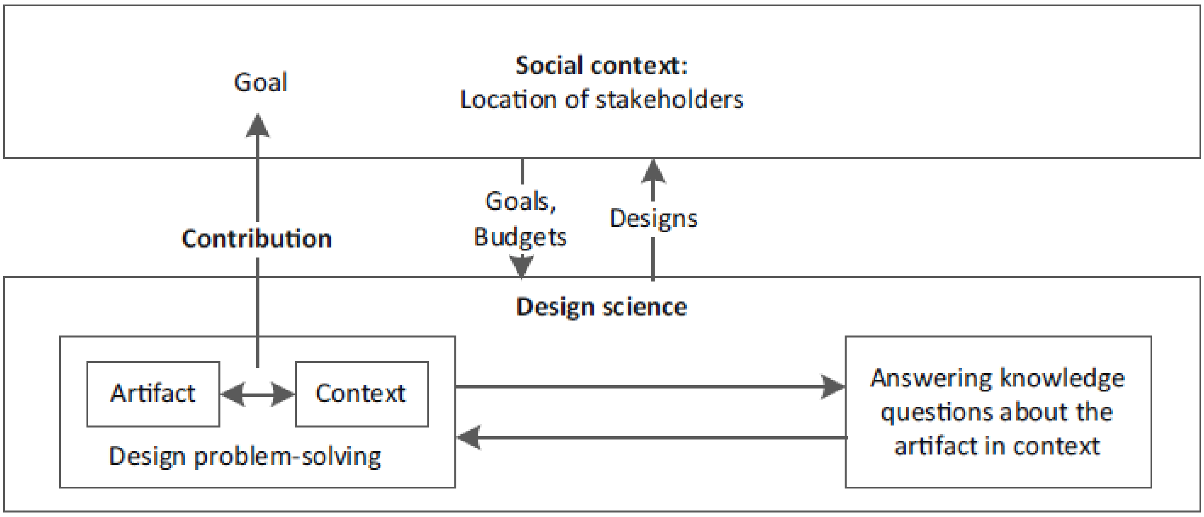


Figure 5 - Interaction of an artifact during the design cycle

Treatment validation

In this stage of the design cycle, the created artifact will be validated on its ability to satisfy the design problem and answer our research question. For this thesis, the validation will take place in a case study at Rexel Nederland. By using this method, we introduce the artifact in the problem context and test its contribution to the design problem. We can validate the artifact by setting up validation questions about the it and study the behavior during the case study.

Finally, at the end of the treatment validation, the results will be described and concluded in the final chapters. Here, we will conclude the outcome of the validation and elaborate on its limitations and future work.

2.2. Design- and knowledge questions

In design science, design problems – or technical research questions – are problems that assume a problem context, stakeholder goal and a call for an artifact. Here, the artifact will interact with the context to help the stakeholder achieve its goal [31]. Design problems are therefore expressed using a certain template.

Improve <*a problem context*> **by** <*(re)designing an artifact*> **that satisfies** <*some requirements*> **in order to** <*help stakeholder achieve some goals*>.

The same applies for knowledge problems where different templates are used depending on the kind of information required from the question. This can be a descriptive, open or closed, or effect, trade-off, and sensitivity question.

Our main research question is a design problem because there is a need for a new assessment model, which needs to be created. Because of this, we will use the template provided which results in the following technical research question:

Improve *the RPA process selection* **by** *creating an assessment model* **that satisfies** *the need for process assessment on RPA suitability and business goal contribution* **in order to** *let business choose the best processes for RPA implementation projects.*

The answer to this technical research question calls for a change of the world, there is a need for a decision model that can be used to support RPA process selection. The solution will be an assessment model.

To answer the design problem and create an artifact, we will answer knowledge questions about the artifact. These knowledge questions are more narrowly focused on specific questions about the artifact and problem context that need to be answered in order to create a suitable artifact. We know the design problem and therefore understand that the thesis must consist of the following parts: RPA criteria for suitability, RPA criteria that support a business goal, a way to score the processes and possibilities to incorporate process mining. This results in the following knowledge questions (KQ):

KQ1 – What criteria make a process suitable for RPA?
KQ2 – What criteria can be used to assess a process on its business goal contribution using RPA?
KQ3 – How can we measure a process on RPA criteria?
KQ4 – How can process mining be used to support the assessment?

These knowledge questions will be the main input and structure for our literature review. We believe that by answering these questions, we can create an assessment model that fulfills the requirements and ultimately solves the gap that is currently present in literature.

2.3. Requirements

As part of design science, requirements are created to provide useful guidelines when searching for possible treatments [33]. In this thesis, the requirements are created for all knowledge questions, and we created requirements for the artifact. These requirements will be used as guidelines during the literature review and design phase. They will help us with determining if the knowledge questions has been answered and contributes to the goals, and if the artifact contributes to the requirements [33].

The requirements for the artifact consist of contribution arguments. These arguments justify the choice for the requirements. According to Wieringa et. al., the contribution argument has the following template: *(Artifact Requirements) X (Context Assumptions) contribute to (Goal).*

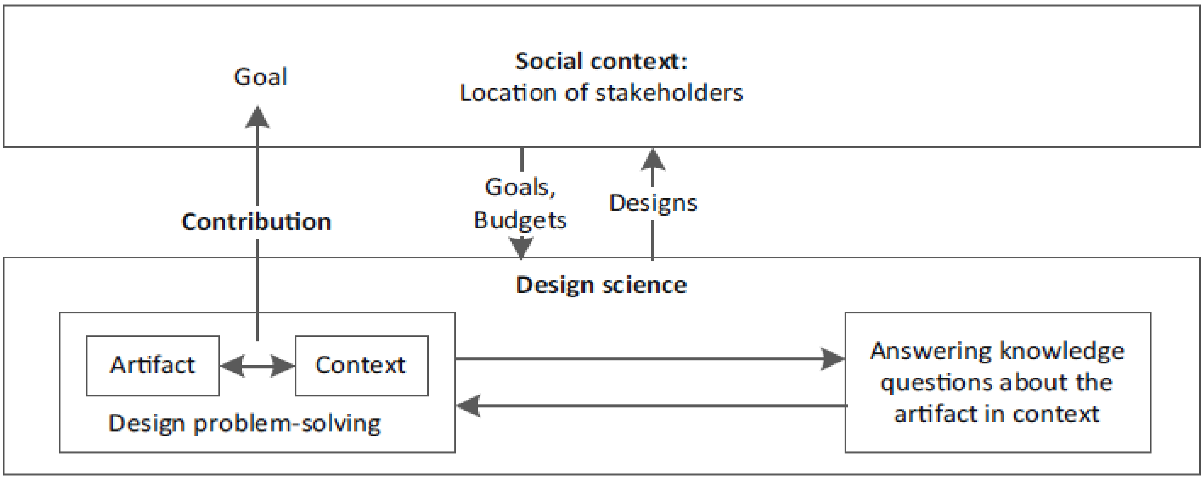


Figure 6 - The place of the contribution argument in the DS framework

The artifact requirements *(R)* and contribution arguments *(CA)* are:

R1 – The artifact must consist of RPA criteria to assess process suitability

CA1 – If the artifact consists of RPA criteria to assess process suitability and the assessor is able to assess the process on these criteria, then the criteria assessment contributes towards the goal of process assessment for RPA.

R2 – The artifact gives business the possibility to assess the process on business goals using RPA

CA2 – If the artifact gives business the possibility to assess the process on business goals using RPA and the assessor is able to assess the process on these criteria, then the business goal assessment will contribute towards the goal of designing an assessment model that can score processes on RPA suitability for business goals.

R3 – The artifact shows what processes are suitable for RPA

CA4 – If the artifact shows what processes are suitable for RPA and the assessor is able to complete the assessment, then the assessment model is able to conclude RPA suitability.

R4 – The artifact supports the use of process mining

CA3 – If the artifacts support the use of non-mandatory process mining and the assessor is able to both perform the assessment with and without it, the model will contribute to the goal of being able to support process mining for the assessment and be applicable for every company.

To meet all artifact requirements, we must know more about the artifact in context and create knowledge questions. When the outcome of the knowledge question meets all requirements, it is deemed as solved and can be used for the artifact design. All knowledge questions are related to the thesis goals and artifact requirements. We also included the origin of the requirement to connect the requirements and the goals of this thesis. We will be working according to the following requirements per knowledge question:

KQ1 – What criteria makes a process suitable for RPA?
KQ2 – What criteria can be used to assess a process on its business goal contribution using RPA?

Requirement 1 – The criteria must have a clear definition.

<u>Origin:</u> According to Syed et. al. [6], it is very important that users will understand what the criteria mean and how these should be interpreted, this is also mentioned as a key challenge in the field of RPA. Criteria are often vague and a lot of companies don't really understand them [34], [35]. We will therefore create a clear definition together with the criteria based on literature in order to make sure that the users of the assessment model will know what they are working with.

Requirement 2 – The criteria must be applicable for all scenarios.

<u>Origin:</u> Our main goal of this thesis is to create a model that can be used by all businesses in all possible scenario's. It is therefore important that there are no sector specific requirements in the model.

We have combined KQ1 and KQ2 due to the relation between the two criteria. Both knowledge questions thrive towards finding suitable criteria but with different viewpoints. KQ1 is focused on understanding process criteria for RPA suitability and KQ2 is focused on finding criteria a process can be assessed upon to support the business goal contribution assessment.

KQ3 – How can we measure a process on RPA criteria?

Requirement 1 – Each criteria must have a measurement connected to it

<u>Origin:</u> Like with the criteria description, it is important that there is a clear understanding of the measurement. The measurement needs to be clear to the assessor so that the assessment model can be used as intended.

KQ4 – How can process mining be used to support the assessment?

Requirement 1 – The use of process mining during the assessment should not be mandatory.

<u>Origin:</u> Our goal of this thesis is to create a model that can be used by all businesses in all possible scenario's. If we make process mining mandatory, businesses without it cannot use the model. It must therefore only be implemented as supporting technology during the assessment. Current literature also shows that not all processes can be used for process mining. If process mining becomes a mandatory part of the assessment, some processes might not be assessable, reducing the use case of the model.

2.4. Literature review methodology

To answer the knowledge questions, we will conduct a literature review. This qualitive method will be used to answer our knowledge questions and so create a good base for our artifact design phase. This chapter will elaborate on the used method in this thesis.

The literature review will be conducted in the so called knowledge context. "The knowledge context consists of existing theories from science and engineering, specifications of currently known designs, useful facts about currently available products, lessons learned from the experience of researchers in earlier design science projects, and plain common sense" [31], [36]. Figure 7 shows the interaction of the literature review with the design science framework.

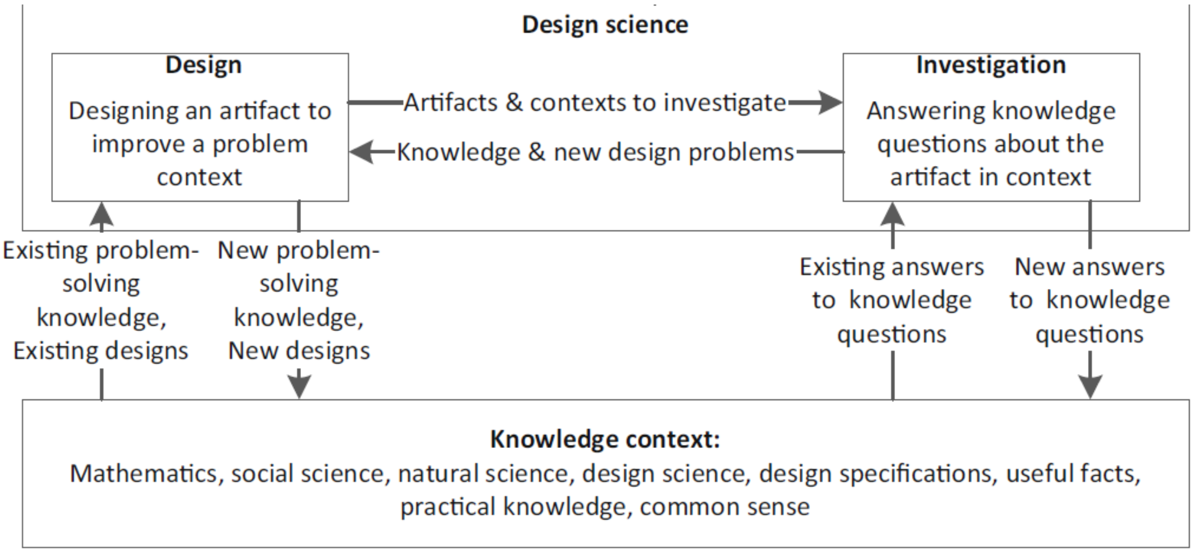


Figure 7 - A framework for Design Science

Looking at the design cycle from figure 4, this literature review will follow up on the problem investigation and thus form the input of the treatment design. The problem investigation is best described in the problem statement chapter, where we describe the current phenomena that needs to be improved. From here, we derive research questions that need to be answered in order to create an artifact [31]. This literature review will provide the basis to form the actual artifact, by finding and documenting the answers to the knowledge questions [31].

Together with the goals, knowledge questions, and requirements, the outcome of the literature review will give a substantiated base to form the actual artifact in the design phase. In the design phase, all the gathered information will be combined to create the artifact.

In order to find the answers to the knowledge questions, we will use the literature review methodology as proposed by Levy et.al. [37] and shown in figure 8. We believe that this method suits the design science methodology well, as its also based on an iterative way of researching and can thus handle any necessary iterations between design and investigation.

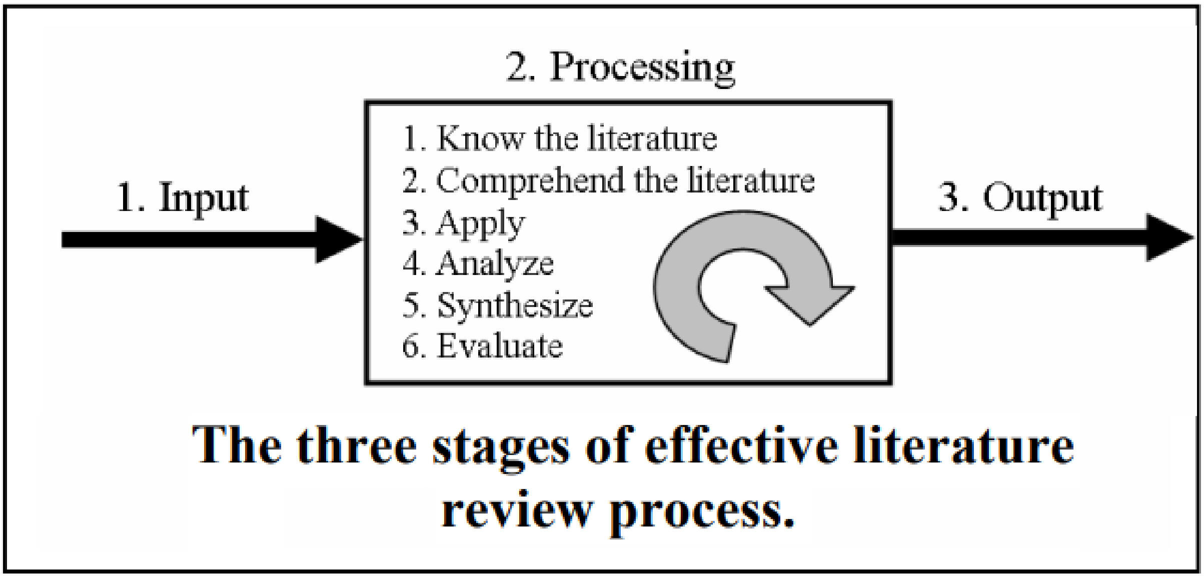


Figure 8 - The three stages of effective literature review process

For the collection of relevant data - the *input* phase of the model – the Search Keys mentioned in chapter 2.5 are used in multiple databases: Google Scholar, IEEE Xplore, Elsevier and ResearchGate. To find and analyze related work the database of ConnectedPapers will also be used. By using these tools, we ensure that the input phase will be a relative complete census of relevant literature [38]. During the literature review, we will also be using the proposed forward and backward searches [37].

When researching these papers, we use a variety which are either based on a real-life experiment, best practice or general studies related to the search keys. This research did not exclude any form of literature. Doing so is important since there aren't a lot of paper available in the field or RPA, let alone on the specific characteristics of RPA [3], [4]. Any paper that can provide us with valuable information is therefore considered and reviewed.

During the second stage of the literature review – the *processing* phase – each paper will be conducted to the proposed processing cycle. This cycle will ensure that the papers are processed in such a way that all relevant information has been understood and reviewed [37]. The processed papers will be categorized per subject and create their own outputs based on the processing cycles.

After the processing cycle all *outputs* of the literature review will be documented in the thesis in their respective chapters. This will create the answer to the knowledge questions and form the base for the design of the artifact [37]–[39].

2.5. Search keys

During this literature, the following search keys have been used to find all used papers. De keys have been used separate or in combination with each other.
Keys: “RPA”, “Robotic Process Automation”, “RPA assessment”, “RPA criteria”, “Process Mining”, “Design science”, “RPA measurements”, “RPA criteria measurements”, “RPA process mining”

3. Literature review

In this section of thesis, we will be focusing on answering the knowledge questions about the artifact with their respective requirements. By doing so, we will create the input of the design phase and artifact. This chapter is based on the literature review method as proposed by Levy et al. [37].

3.1. RPA criteria

In order to answer the research questions: "*KQ1 – What criteria make a process suitable for RPA?*" and "*KQ2 – What criteria can be used to assess a process on its business goal contribution using RPA?*" we need to research the current literature on RPA criteria. This section of the thesis will therefore focus on researching existing literature – the knowledge content [31] – in order to find out what process criteria are important for RPA in order to be successful and applicable. These criteria will later be used to create the actual assessment model.

We will interact with the knowledge content on both existing RPA process assessment models as well as existing RPA literature regarding the process assessment criteria and findings from actual use cases of RPA process assessment. The goal is to combine everything found in the knowledge content and combine it to a clear list of criteria with accessory definitions.

The list of criteria must not only consist of a criteria, but also consist of a clear and sustained definition. According to Syed et. al. [6], it is very important that users will understand what the criteria mean and how these should be interpreted, this is also mentioned as a key challenge in the field of RPA. Criteria are often vague and a lot of companies don't really understand them [34], [35]. We will therefore create a clear definition together with the criteria based on the criteria that will be found in literature in order to make sure that the users of the assessment model will know what they are working with.

To answer the knowledge questions, we will generate a list of relevant criteria and definitions based on the finding from out literature review.

3.1.1. Types of criteria

As stated in the introduction chapter, current assessment models are not able to assess a process on the business goal contribution of RPA implementation. This results in – as seen at Rexel – failing RPA projects and implementation results not meeting their expectations. As suggested by Wanner et. al., the assessment on RPA suitability should not only be done based on technical requirements, but should also incorporate business impact and goals during the assessment of a process [20].

In order to find out how we can incorporate business goal assessment into our assessment model, we started the literature review by analyzing if such criteria are currently present in literature. During this literature review, we found that current models mainly consist of the technological criteria required to implement RPA in a process. These criteria must be present in a process in order for RPA to be implemented, without these criteria RPA is unable to be implemented. We marked these criteria as "essential". If a process does not meet these essential criteria, it is not possible to implement RPA.

The literature review also showed us that RPA has certain known benefits on a process after implementation. If implemented correctly, RPA implementation can for example have a fast return on investment, increase customer satisfaction or increase the process transparency. These are also known business goals when implementing RPA [3]. One of these known benefits have been highlighted by Wanner et. al., who created an assessment model around the short term return on investment of a process after RPA implementation [20]. By doing so, he shows that it is possible to assess a process on its business goal contribution after RPA implementation. Business sometimes implement RPA to meet their business goal based on fast ROI RPA implementation. Unlike the essential criteria, having a fast ROI is not essential in order for RPA to operate in a process. A fast ROI, or the ROI in general, is a known benefit of the RPA technology on a process after it has been implemented.

By measuring certain aspects of the process, Wanner et. al. quantifies the expected short-term ROI based on certain process characteristics that he assesses before RPA implementation. This assessment of the process then helps businesses to decide if the ROI meets their business expectations and if the process is suitable for RPA implementation based on the business goal and expected benefit.

Thus, if a company wants to achieve an objective through RPA implementation, it is important to know whether RPA implementation actually adds value that contributes to the achievement of these business goals. This can be done, as Wanner et. al. showed, by quantifying a known benefit of RPA and then measuring this per process. By doing so, it becomes known whether RPA can actually provide a benefit in this process that is relevant to the business goal.

Rexel Nederland's goal is to reduce the number of FTE required to perform a process, with the objective of saving one FTE after RPA implementation. A well-known benefit of RPA is saving FTE by having bots take over the work of employees. By measuring a process and then being able to quantify how many FTE the implementation of RPA on the process will actually be, a company can assess whether the implementation contributes to the business goals.

These known benefits will be "business criteria" in our assessment model. These are criteria that represent the known benefits of RPA and from which a company can expect that these aspects of a process will improve after RPA implementation.

Essential criteria
A lot of the current literature on RPA process assessment is based on criteria that a process must consist of in order to use RPA. Assessing a process on these criteria will let the assessor know if RPA implementation is possible [11], [20], [26], [29]. If a process meets these criteria, RPA technology can be used in the process. Without them, RPA is not an option. These criteria are connected to the minimum technical requirements RPA has. In our thesis we will be referring to these criteria as "essential", because if a process does not meet these criteria RPA cannot be implemented in the process. Making them essential for RPA implementation.

Business criteria
Implementing RPA in a process is never the actual goal of an RPA project. The implementation will always be used as a tool to meet a certain business goal [9], [10], [26]. Assessing a process on just the essential criteria will therefore not tell a business if RPA will help them towards this goal. The essential criteria will only show the assessor that the process is suited for the implementation of RPA.

Businesses should therefore not only focus on these essential RPA criteria but extend their process assessment to see if RPA implementation actually contributes towards their business goals. Multiple sources have stated that it is very important to assess processes on non-technical criteria, also known as business criteria. These criteria help to assess a process on its viability towards business goals an KPI's [9]–[11], [15], [20], [26], [29].

Business criteria are often not mentioned in the current assessment models, but are mentioned in the discussions or future work chapters [9], [20], [26], [29]. Experts state that these business criteria are important, but they should not be too scenario specific. This could harm the generalization level an assessment model must have in order to be applicable in multiple scenario's [9], [10], [20], [29].

A business criteria in this thesis will be a process criteria that is known to be positively impacted by RPA implementation. These criteria do not influence the implementation in such a way that RPA can be implemented in general but will assess a process on benefits RPA implementation can have. By assessing a process on these criteria, businesses can determine if the implementation of RPA on a process will help with achieving their business goals.

Conclusion
During the literature review, we found two types of assessment criteria: essential criteria, and business criteria. Essential criteria are the criteria a process must have for RPA to work. Without these characteristics, RPA cannot be implemented. Business criteria are based on the expected benefits RPA implementation can have on a process. Unlike with the essential criteria, these do not specifically impact the implementation possibility of RPA, but rather focus on business goal contribution.

3.1.2. Criteria selection

Now that we understand that there are two types of RPA criteria, we continue the literature review to answer KQ1 and KQ2. In this section, we research the knowledge context with the help of our search keys. This creates a set of researches that we use as our input for the first processing iteration [37].

The first processing cycle is focused on finding all known essential- and business criteria. When analyzing the knowledge context, we find that many sources use different terminology for the criteria resulting in ambiguous criteria throughout sources. To comply with our requirements for this knowledge questions, it is important to have a clear understanding and definition of the criteria. We therefore created one main criteria title based on the existing criteria found in literature. After the processing cycle, the output of the first literature review creates a list of criteria with their respected descriptions per source. This list can be found in appendix 9.2 – First iteration of RPA criteria.

After this first literature review iteration, we can not yet answer our knowledge questions. Looking back at out requirements for these knowledge questions we can see that there is currently not one clear definition available for the criteria – requirement 1. In order to do so, we merged all the source definitions per criteria to one main definition. This definition will be used in our thesis and will be the main definition provided with the artifact.

To fulfil the set requirements for both knowledge questions, we conduct a second literature review iteration. This iteration is focused on creating one definition that will be used within the assessment model and divide the criteria in business and essential. As also discussed in Agaton et. al. [29] current criteria found in literature are not identical and may have small deviations in the criteria's explanations. We therefore create a new explanation for each criteria of the model in the second processing iteration.

We do this by analyzing the existing definitions found in literature on similarities and contradictions. Then, based on this analysis, we determine what the definition will be for our assessment model. This way, we ensure that an unambiguous definition is created per criteria that users of the model can use, and which should eliminate any confusions or misunderstandings of the criteria. An important step [6], [34], [35].

By conducting the literature review iterations, we found an answer to KQ1 and KQ2 in the form of criteria and criteria definitions. This list is shown in table 1. Together with the more elaborate explanation described in chapter 3.1.3 – criteria elaboration, we believe that KQ1 and KQ2 are answered and meet their requirements. This list will serve as one of the main inputs for the design phase of the thesis and creates a literature-based input for the assessment model.

Tabel 1 shows all seventeen criteria that have been found in the literature review. All criteria have been grouped by their respective criteria type: essential or business. All criteria also have a connected definition in order to better understand the goal and meaning of the criteria.

Table 1 - RPA criteria and definition

Type	Criteria	Definition
Essential / Business	Standardization	Exceptions are deviations from the main process that need to be programmed differently into the RPA bot. Processes with fewer exceptions are better RPA candidates. Standardization of a process is high when the number of process exceptions are low.
Essential	Rule based	RPA processes need to be defined in business rules. Processes that are highly rule based can be used for RPA implementation. Processes or tasks that require creative thinking and aren't rule based aren't suitable for RPA implementation.
Essential / Business	Data quality	Data quality consists of four factors; it must be digitally available, the data structure must be supported by the RPA bot, data must be carefully defined, and the data shouldn't contain surprising values. Otherwise, the RPA bot might not work, or perform unexpected behavior. Processes with high data quality are good RPA candidates.
Essential / Business	Maturity	Maturity is based on the number of planned changes to a process. Low amounts of planned changes result in a high level of maturity. The higher the maturity, the better a process is suited for RPA.
Business	Number of involved systems	The number of involved systems a process interacts with in order to be completed. The higher the number of involved systems, the more benefits can be expected from an RPA implementation.
Business	Frequency	The number of times a process is performed daily. Processes that have a high frequency are more suited for automation than low frequency ones. The higher the frequency, the more cost reduction opportunity an RPA implementation will have.
Business	Human error	The number of errors in the process due to human interaction. Processes that have a high number of human errors are good RPA candidates. The RPA implementation will most likely reduce this amount and thus create greater benefits over processes with low amounts of human errors.
Business	Return on investment	The amount of time it takes for an RPA implementation to be profitable. High return on investment processes are good RPA candidates.
Business	Employee satisfaction	Processes with low employee satisfaction are good RPA candidates. RPA can often take over these unsatisfying tasks and increase the employee satisfaction.
Business	Process quality	Process quality refers to the degree a process meets the needs and expectations of the process according to its stakeholders. RPA is known to increase process quality.

Business	Time saving	RPA can reduce the amount of time a process takes to complete. Processes that require time saving or have high execution times are therefore good RPA candidates and will likely see a reduction in throughput time after implementation.
Business	Availability	RPA can increase the availability of a process after implementation since RPA can be active 24/7. Processes that require higher amounts of availability are therefore good RPA candidates.
Business	Efficiency	The amount of time spend on value adding activities in the process in relation to the total available time.
Business	Reassign employees	The implementation of RPA can result in the reduction of human interaction with a process. This saved time can be used by companies to reassign employees to other, more value adding tasks. Processes that result in the possibility to reassign employees are therefore good RPA candidates.
Business	Customer satisfaction	Processes that result in low customer satisfaction can be good RPA candidates. By improving these processes using RPA, the satisfaction can increase.
Business	Transparency	The combination of documentation, log-files, and detection of integrity errors makes that RPA can improve a process' transparency. Processes that require more transparency, or good transparency in general are good RPA candidates.
Business	Reporting	RPA bots log all their activities. As a result, more data becomes available to analyze and base reports upon. Processes that require more reporting or reporting in general are good RPA candidates.

3.1.3. Criteria elaboration

This chapter elaborates the criteria and definitions from table 1. Here we will explain the criteria and definition in more detail based on the findings of the literature review.

Standardization

Standardization has been mentioned in most of the RPA research. It is sometimes also mentioned as 'exceptions'. In this thesis, we will be using the term standardization since this has more mentions in literature. The standardization criteria is focused on the number of exceptions a process has to its standard flow.

An RPA bot needs to be programmed for each step it will perform [35]. When a process has a lot of exceptions – and is therefore not standardized – each of those exceptions need to be programmed into the bot in order to automate a process. This will create a very complex and time-consuming implementation process. A process that has less exceptions and more standardized outcomes of executions is therefore better suited for RPA and will have a faster implementation time. The higher the standardization, the better a process is suited for RPA [11], [20], [26].

This criteria is classified as a combination of essential and business criteria. Multiple researches show that when a process has a low level of standardization, it will have a high possibility to fail or become very expensive to automate [7], [16], [22], [27], [40]. In this case, it is better to first simplify the process before assessing the process again and eventually implement RPA if possible [7], [15], [22], [27], [41], [42]. Based on these outcomes, standardization would be an essential criteria. If the level of standardization is too low, the likelihood of failure increases and due to the necessity of programming each exceptions, the cost and throughput time of the implementation are unlikely to out way the benefits. Research therefore states that these low standardization processes are unsuited for RPA.

On the other hand, most RPA vendors have options to handle exceptions by programming the exceptions into the RPA bot or making use of an alternate flow. This alternative flow shows a key-user any exceptions to the standard flow if they occur. From here, an employee could manually handle the exceptions the RPA bot could not perform. Processes with low amounts of exceptions could therefore still be suitable for RPA implementation [43]. Having high levels of standardization can also be of importance to business goals. Businesses seeking for fast and reliable implementation can focus on processes with high levels of standardization, because these are known to be faster and relatively easy to implement.

The above literature review showed us that there is a certain point where standardization becomes essential due to the expected drawdown of implementation, and in other scenario's it can be seen as a business criteria. In chapter 4.1 – measurement per criteria, we will create a line of demarcation between the essential and business side of the standardization criteria based on the measurement outcome.

Rules based

Rule based processes are key to a successful RPA implementation. Without any business rules, RPA bots won't be able to work [16], [18], [44], [45]. The way RPA works is that the RPA bots follow a pre-defined set of rules that are programmed in the RPA bot. This bot can then perform a series of actions based on these rules and so perform a process.

A process is highly rule based when the activities in that process do not require a lot of creative thinking by employees. If a process is highly creative and requires an employee to react different in each situation, the process is very likely not rule based. A rule based process is known for a low level of required creativity. The process is performed in a set order based on the input and the process is always performed via rules and set workflows. These processes do not require creative thinking and even leave little room to even do so [6], [16], [22], [46].

Because RPA bots are based around performing rules to complete a process, it is crucial that a process can be defined by business rules. All sources agreed that RPA cannot be implemented on processes that require creative thinking in order to complete the process. The process must consist of a clear input, process flow and output.

There are upcoming RPA bots that are able to handle more creative processes with the help of Machine Learning (ML) and Artificial intelligence (AI), these are however not commonly used as of today and not a lot of research is available on them. We therefore deem them out of scope for this thesis. Future work could extend on the possibilities of this bot and possibly adjust the assessment model accordingly [47]–[49].

Being able to define clear business rules for a process or tasks is essential to a successful implementation of RPA. Without the ability to define rules for the RPA bot, it won't be possible to implement RPA. Santos et. al. [11] therefore even states that businesses must first assess a process on its rules, before assessing any further. Making rule based an essential criteria to RPA process assessment.

Data quality

One of the main sources of a successful RPA implementation is the data quality RPA bots have to work with [50]. Most RPA bots perform "if, then, else" statements on structured data in order to perform their tasks [51]. There are certain RPA solutions that can work with unstructured data, often due to a combination of ML and AI and some that require specific data characteristics. To support implementation it is therefore important that the data structure matches the required RPA data structure [16], [27], [46].

A high data quality is important to RPA. Processes that consist of low quality data are deemed unsuitable for RPA because it will lead to errors in the process execution [6], [50]. The data quality for RPA is determined by the following factors according to [6], [11], [16], [27], [46], [50]–[52]:

- **The data must be digitally available > Essential**
  - Without digitally available data, RPA won't be able to perform its tasks. This is a key factor for RPA implementation. RPA isn't able to perform actions on data that is non-digital, making it an essential criteria [6], [11], [16], [26], [27], [46], [50]–[52].
- **Consistent, doesn't contain 'surprising' values and undefined datatypes > Business**
  - If the data contains inconsistent values, the RPA bot can behave in unexpected ways. RPA can handle some unexpected data types, but with every 'surprise' comes an exception that needs to be addressed [11], [46], [50].
- **Data structure must match the supported RPA data structure > Essential**
  - With an unsupported data structure, the bot wont be able to interpret the data as intended. If a company want to use an unsupported data type, it must first transform the data to the supported type. Otherwise the bot will result in an error [6], [16], [26], [27], [43], [46], [51], [52].
- **Data must be carefully defined > Business**
  - When data is defined and documented, the risk of a faulty interpretation will be lowered due to up-to-date documentation and information about the process. A wrong interpretation can lead to unexpected behavior after implementation or being unable to implement RPA. It is therefore important to have good documentation about the data that will be used [6], [50], [52]. If there is no documentation available, it is recommended to first create documentation in order to reduce the chance of errors during implementation [7], [15], [17], [41].

The data RPA has to use is crucial to a good implementation and use of the bots [50]. It is therefore classified as an essential criteria in our assessment model. However, as shown above, the data quality consists of multiple criteria and can therefore consist of different variations per assessed process/ task. We therefore classify all underlaying data quality criteria in essential and business.

Both digitally available data and structured data are classified as essential. Without these, RPA won't be able to fulfill its business rules and thus won't be operatable.

The presence of surprising values is classified as a business criteria. Whilst exceptions can cause the RPA bots to behave in unexpected ways, there is also a way to monitor and handle these exceptions. This is called exception handling. Exception handling and logging often consists of: exception handling, logging of errors, debugging, collecting crash dumps, and error reporting [43]. Because RPA can handle exceptions, we have classified "surprising values" as a business criteria. To many surprising values and the bot will be handling more exceptions than not, but a couple of exceptions can still be handled by RPA. This way, RPA can still work with some exceptions, but less exceptions make for a better suitable process. Here, businesses looking for a clear implementation and ultimately a bot that does not require lots of management will focus on processes with low levels of surprising values.

With undefined data, the changes of a failed implementation increase [50]. This is because the knowledge level of the available data is low and thus more difficult to assess. It is therefore important to have carefully defined datasets and base the assessment upon that. Without this RPA can still function, as long as the data is digital, consists of the right structure and doesn't contain surprising values. Having up-to-date data will benefit the implementation process and will likely lower the chance of a failed implementation.

Maturity

Processes that have a high level of maturity are suitable RPA candidates according to our literature review. A high level of maturity is based on the duration a process stays unchanged. Changes to the process that are planned in the near-future result in a low level of maturity [11], [20], [26], [35].

Having a high level of maturity will decrease the change of rework and will increase the availability of the bots. RPA bots work based on a set of rules and perform accordingly. When there are changes in to process, these RPA bots need to be adjusted to the new process in order to function as expected [26], [46].

The model will use maturity as a business and as an essential criteria. Like with the standardization criteria, we can determine a cut-off point in which maturity can be an issue to the implementation. We know that the return on investment duration of RPA projects rarely is below three months [40], [53]. This will be used as the threshold for the essential criteria. When the expected changes are planned outside the first three months of use, maturity becomes a business criteria. Three months is also the estimated time it takes to implement an RPA bot on more complex processes [68]. When changes are planned within three months, it is better to wait for the change to be implemented and then start with the implementation of RPA. This will be further elaborated in the design chapter of this thesis.

Maturity is essentially a business criteria because RPA can still function well with low levels of maturity. However, low levels of maturity will eventually result in rework and thus less availability and higher costs [20]. If a process passes the essential criteria check, maturity is being assessed in more detail as a business criteria. This is because a high level of maturity contributes to the availability of the bot and will thus result in more consistency throughout the RPA lifecycle, which can be of interest by businesses. Processes that have high levels of maturity e.g., a long period without planned changes, will score higher for RPA suitability than processes with a shorter period without planned changes. The exact scale will be elaborated in the measurement section for maturity.

Number of involved systems

Processes that require access to multiple systems in order to be completed are good RPA candidates. Performing tasks in multiple systems by humans can result in an increase of errors and a long throughput time. The higher the number of involved systems, the more likely a process will benefit from RPA. These processes are more suited, because the benefits are likely greater than processes that only have one involved system due to the expected benefits coming form RPA implementation [11], [16], [17], [27], [40].

Transferring data for example from multiple input sources to one system can easily cause errors. By using RPA bots, these tasks can be performed much faster and with less errors [17], [26]. Bot are able to switch systems and work simultaneously in multiple systems much faster than humans can [26], [27].

The number of involved systems is categorized as business criteria. RPA can still be implemented with a low number of involved systems; it is therefore no essential criteria. The potential benefits of RPA however get greater when more systems are involved. Businesses could therefore aim to implement RPA on process that involve multiple systems in order to maximize the RPA implementation potential, reduce errors, and increase processing speed.

Frequency

Frequency represents the transaction volume of a process. This is an absolute number that is being measured over the period of one day [26]. Processes that have a high frequency are better suited to be automated with RPA. This is because bots are able to process steps faster and more accurate, the higher the frequency the more gains can be expected from the RPA implementation. High frequency tasks are therefore also considered as an opportunity of cost reduction [7], [11], [16], [20], [35], [44].

Aalst et. al. [5] shows that RPA relevancy lays in the case types that are not feasible for general automatization. Generally, the top 20% of case types make up for 80% of the case frequency. These are the processes that are often addressed using general automatization. This leaves a long-tail of the remaining 80% of case types responsible for the remaining 20% of the case frequency. These final case types are a lot less frequent and because of the lack of automatization more time consuming.

A great part of this long tail is suitable for RPA implementation. These cases are not frequent enough to justify traditional automation but are repetitive enough to make a light-weight solution like RPA a possible automatization option. In this final end of this long-tail, there are case types that are so rare and therefore best to be handled by human employees in an ad-hoc manner [5].

So, frequency is a great indicator to measure possible RPA use cases and their suitability. Whilst high frequency processes are often best to be automated via traditional process automation, a remaining 80% of the case types cannot be automated using this traditional process automation, making it suitable for RPA.

The frequency of a process is classified as a business criteria. RPA can still function on processes that have a very low frequency and can therefore not be classified as an essential criteria. A process with higher frequency however will offer economies of scale and so allow companies to realize significant cost reductions and leverage the returns of automation [20], [26].

Human error

RPA bots have a couple of main benefits over human employees, one of these benefits is a lower level of errors. RPA bots are less likely to perform a task with errors than humans would, especially when executing monotonous and voluminous tasks since these negatively impact the focus of employees and cause errors in the process [11], [20], [26]. RPA bots are not subjective to human characteristics like loss of concentration [26], [27]. Processes that are currently prone to human errors are therefore great RPA candidates. The introduction of RPA bots is known to reduce the human errors, resulting in a process with less errors that is thus more efficient [11], [16], [26], [27], [35].

Proneness to human error is classified as a business criteria. RPA can be implemented in processes that have low levels of human errors and still function. However, past implementations show that RPA implementation can reduce the number of errors in a process compared to employees. Processes with high levels of human error will likely benefit more form RPA implementation. Implementing RPA in these processes will result in cost reduction and improved efficiency as a result of the error reduction [16], [27].

Return on investment

Although expert say that RPA implementations shouldn't always be about financial benefits [20], companies often expect to see good returns after the RPA implementation. This is especially due to the relative small initial invest that RPA requires compared to an FTE or other forms of automation [21], [27]. Some studies have proven that RPA implementations can give positive ROI's of around three to six months up to a year with annual returns from 3,000 – 8,000 dollars [21], [40], [45], [53].

Research performed by Wanner et.al. [20] shows a way to solely assess RPA processes on their return on investment. This model aims to help business that seek to prioritize their RPA activities on it's return on investment by focusing on maximizing the short-term economic success of RPA projects.

Research has shown that RPA can have a faster Return on Investment compared to other forms of automation or compared to human labor (increase of FTE). Businesses that implement RPA are therefore often also interested in the actual Return on investment. We will incorporate this assessment in our model. Processes that have better ROI are therefore good RPA candidates over processes that have a worse ROI. This will be classified as a business criteria.

Employee satisfaction

RPA experts state that the implementation of an RPA solution isn't always about the money side of business [20]. An RPA implementation can also be performed with the goal of increasing employee satisfaction. According to Kroll et. al. [27]. RPA taking over certain tasks and processes can minimize the stress curve and have a positive effect on both employee satisfaction and health. When assessing employee satisfaction, this should be based on the process that is in scope for RPA implementation.

An increase in employee satisfaction by RPA is often achieved due to the relieve of repetitive and mundane tasks. Most employees have better moral when they invest their time and talent in jobs that are more interesting and less routing [3], [9], [22]. This can be achieved by reassigning the employees or by an RPA bot that takes over these routine and mundane tasks. Employees can then focus on more complex tasks that will increase their satisfaction [10], [13], [26], [44].

Tasks or processes that have low levels of employee satisfaction are therefore good RPA candidates. Implementing RPA in these processes can increase the employee satisfaction. If it doesn't, RPA can still be implemented. Employee satisfaction is therefore a business criteria.

Process quality

RPA is known to increase the process quality after implementation [3], [9]–[11], [16], [22], [26], [27], [40]. This is because RPA has the ability to perform the same tasks human do, but with less errors, higher efficiency, and in less time. Process quality can be very different, depending on the process and requirements of that process [54]. Research found that quality can be an aspect that differs per process, company and even person [55]. It is therefore very difficult to provide a clear definition of quality that will be generic enough so that everyone can still use this assessment model and specific enough so that it fits the process, company and persons definition of quality.

Our definition of process quality meets the outcome of research in a way that every assessor understands the concept, but can still tailor fit the definition to its needs. By using this generic definition in combination with our measurement option for process quality, we aim to achieve an assessment that can focus on process quality and can be adjusted to every assessor's needs.

Process quality is a business criteria since processes with high quality can still be used to implement RPA. They will, however, benefit less from the implementation in term of process quality increase. It is also unlikely to implement RPA in processes that have high quality, because RPA gets implemented to improve a process, implying low levels of quality.

Time saving

Time saving is one of the most anticipated outcomes of RPA implementation [27]. It is therefore important that the assessed processes are also assessed on this topic and thus makes part of the assessment model. Research shows that RPA can safe up to 70% of the total time of a task or process [27]. One sources even showed that the turnaround time was reduced from days to just minutes by implementing RPA [17]. Processes that require time saving or currently have high execution times [20], [44], [46] are therefore good RPA candidates.

Saving time by implementing RPA is often achieved by reducing errors, improving the processing speed, and replacing human employees with RPA bots. Ultimately reducing the cycle time, freeing up personnel and saving time [3], [7], [10], [11], [16], [26], [40], [44]. Saving time isn't a given result when implementing RPA, some use cases showed that the implementation of RPA didn't save any time but only freed up employee time [11], [17]. It will therefore be important to assess the processes or tasks on the amount of saved time if businesses like to focus on improving this section. Having a long execution duration is often a quantifiable indicator of the time-saving potential [20], [26].

Due to the characteristics of RPA, time saving potential can often be estimated based on the known benefits of RPA. Processes that require comparisons between different applications, data adjustments, or data entries can often benefit from RPA. Bots can perform these actions faster than humans can and so save time in the process [41], [52], [56].

Time saving is a business criteria. Processes in which not much time can be saved are not directly unsuitable for RPA. These processes can still be used to implement RPA. However, assessors should keep in mind that the time saving potential of RPA will likely not be optimized in these processes.

Availability

One of the perks of RPA is the continues availability of the bots. RPA bots are able to run 24 hours a day, seven days a week without the need of any breaks [27], [40]. This gives the opportunity for businesses to run certain tasks or processes around the clock without the need of employee availability. Extending the availability of the processes and decreasing the dependency of personnel [3].

Implementing RPA on processes that require more availability can therefore give companies an edge over human employees [10], [13]. However, processes that do not require an increase of availability or wont benefit in term of availability are still suitable for RPA. Availability is therefore classified as a business criteria. Businesses can consider the increased amount of process availability when assessing a process.

Efficiency

According to research, 86 percent of RPA users believes that RPA helps increase efficiency [27]. Use cases have shown that RPA implementation can increase efficiency with over 60% [40], [57]. Efficiency is often defined as a situation in which a person, company, factory, etc. uses resources such as time, materials, or labor well, without wasting any [58]. According to [11], [13], [16], [26], [27], [40], [44] processes with low efficiency (i.e., wasting available resources) are good RPA candidates. RPA can often increase the efficiency by decreasing the turn around times and reducing errors. Ultimately optimizing the available time [11], [40], [44].

Processes that have low levels of efficiency are good RPA candidates. RPA can often increase the efficiency by reducing the number of errors and decreasing the turn around time resulting in more useful time to perform tasks. Efficiency is a business criteria since RPA can still be implemented in efficient processes.

Reassign employees

RPA implementations that result in great possibilities of reassigning employees are good RPA candidates. Reassigning employees can be a result of RPA implementation. Many companies have shown that their RPA implementation lead to the reassignment of employees to more value adding tasks [9]. By implementing RPA, tasks of human employees can be taken over and performed by the bots. This will increase the amount of available time for employees to do other activities. Companies are striving towards reassigning the employees to do more value adding tasks then they did before the RPA implementation [11], [27].

Most of the used sources suggest the reassignment of employees towards more challenging and value adding tasks then they did before the RPA implementation [3], [9], [11], [22], [26], [46]. Some more recent researches are also acknowledging the need for RPA personal in companies and therefore suggest that employees need to be reassigned to RPA-related tasks [13], [40]. In the end, this comes down to the business needs and goals.

Reassignment of employees is also a business criteria. Businesses might decide to focus on the reassignment of employees as a way of increasing the satisfaction, improve the occupation rate of value adding tasks or fulfill new RPA-related jobs.

Customer satisfaction

By reducing errors, decreasing throughput time and improving over all efficiency, RPA has the potential to greatly improve processes. These improvements can in certain points help business improve on their customer satisfaction [9], [13], [17], [40]. An implementation described in [17] showed that customer related activities had reduced throughput times and error rates by 50%, resulting in faster and higher quality resolution, increasing the customer satisfaction.

Implementing RPA in area's that are directly connected to customers can have great impact on the satisfaction. RPA can help resolve low priority customer service issues, create regular service updates or help to reassign employees to customer related activities and add value there [20], [22]. RPA implementation can also indirectly impact the customer satisfaction. RPA can free up FTE, which can be reassigned to more customer related activities, increasing the customers satisfaction of the process.

Processes that are currently low on customer satisfaction are therefore great RPA candidates and will benefit more from RPA implementation. By improving these processes with the help of RPA, there is a great chance of also increasing the customer satisfaction. This business criteria can be used by businesses spot the processes that will most likely have an increased customer satisfaction after implementation.

Transparency

RPA implementations require multiple steps in order to be completed [9]. During these steps, it is important to create good documentation of its process-steps. These steps are more difficult to find after implementation and should therefore be made before implementation [9]. A main benefit of this documentation is the increased transparency of the RPA bot and thus the tasks it performs. The bots will always follow this documentation and the steps and rules that are documented in the bot [23].

RPA bots are also logging every step they take in log-files, errors are also logged in separate error log-files [59], [60]. Essentially leaving an audit trail for each step. These logs can also detect possible data integrity errors and enable standardization. The combination of documentation, log-files, and detection of integrity errors makes that RPA can improve a process' transparency [22], [23], [44].

The improved transparency has been classified as business criteria. A process could already be very transparent and might not benefit a lot from RPA, if this is the case – RPA can still be implemented. Businesses looking to increase the transparency of a certain process can benefit from the implementation of RPA.

Reporting

The improved reporting capabilities via RPA implementation comes from the fact that RPA bots log all their actions [40]. RPA logs can be used as input for reports, analysis and eventually be used to improve the process and spot bottlenecks. This can be of great value for businesses. Processes that need improved reporting or don't have any reporting options right now are therefore good RPA candidates [22], [40]. Reporting is a business criteria. RPA is not dependent nor made for reporting purposes. However, businesses are using RPA to improve their reporting, and this can therefore be a valid business criteria for some.

3.2. Measuring RPA criteria

This chapter aims to answer KQ3 – "How can we measure a process on RPA criteria?". Now that we understand what criteria are important when it comes to RPA process assessment, we need to understand how we can assess a process on these criteria. Assessing a process on these criteria means that a business can use the selected criteria to find out if a process is suited for RPA and if they help achieve their business goals. All criteria therefore need a measurement characteristic to show the degree of satisfaction a process has on that certain criteria.

By researching the criteria's corresponding measurement, we aim to satisfy one of the goals of this study, namely, to create a model that can score processes on RPA suitability. We will achieve this by combining the RPA criteria found in chapter 3.1.2 with their own measurements researched via a new iteration of literature review.

In order to find these measurements, we will primarily focus on the existing knowledge content. As found in the previous chapters, research has been conducted on the right criteria for RPA. We like to extend on this and research the existing knowledge content on used or proposed measurements for these criteria. These measurements will be documented and later be used in order to design the assessment model.

For the first process review cycle [37] we use the input sources found in our research on RPA criteria. These sources mentioned the criteria and proposed them as relevant for RPA process assessment and some used them in actual use cases. We will apply the review processing steps on these studies and extract relevant measurement information per source and criteria. The first iteration results can be found in appendix 9.3 – First iteration of RPA criteria measurements.

These results shows that not all sources are able to provide helpful measurement information. This is often because the sources mentioned the criteria as important but didn't state how they should be measured. Most of the time, sources that incorporated use cases into their research had valuable information on the measurements of each criteria. For criteria where most of the sources give a measurement option and where the options are comparable, we can decide on one concluding measurement option. This is the case for criteria: Standardization, Rule Based, Frequency, Number of Involved systems, Data quality, Maturity, Human error, Return on investment, Time saving, Availability, Reassign employees, Transparency, and Reporting.

Criteria where it isn't possible to conclude such an option – because there aren't enough measurement options from the first iteration, or the measurements weren't comparable – need further research via a second literature review iteration.

The following criteria will be further researched in iteration two:

- Employee satisfaction
    - The sources mention the reduction of repetitiveness, performing non value adding tasks, and reduction of boring tasks as the main measurement for employee satisfaction. One source mentions interviewing the employees to find how satisfied they are with the process. We like to research if we can find a way to measure employee satisfaction directly by the employees instead of using potential RPA benefits as an assessment criteria. This will eliminate the change of misconceptions and fallacy.
- Process quality

    - Process quality is different for each process, company, and person. We are therefore unable to find a suitable measurement option for process quality in the RPA literature.
- Efficiency
    - Efficiency is defined in the sources as a reduction of errors and reduction in TAT. Because these are already separately measured, we will research another way of measuring efficiency. The aim will be to measure as close to our defined definition being the amount of spend time on value adding activities.
- Customer satisfaction
    - Two sources mentioned that customer satisfaction goes up when the number of errors and the TAT is reduced due to RPA implementation. Other sources didn't mention any ways to measure customer satisfaction. These measurements are already being used in order to assess a process. We therefore decide to further investigate any customer satisfaction measurement options.

For the second iteration, we resort to non-RPA related studies in regard to the criteria that do not have any RPA related measurement suggestions. We find that most of these criteria are also being used in different contexts and research fields, opening up to a much wider knowledge context that can be used to create a suited measurement option.

Employee- and customer satisfaction are well established criteria in other fields and have a lot of research on them. We found that the definition of customer- and employee satisfaction was not any different in these contexts compared to the RPA context. Both customer satisfaction and employee satisfaction measurements are therefore based on suggested measurements by studies from different fields. We adapted these measurements will use them in the RPA context for our model.

For process quality and efficiency, most research is available in the field of manufacturing. We find that especially research in the lean manufacturing field gives us great insights. The theories on efficiency and process quality in lean are very detailed and have also shown to be applicable in other fields than manufacturing. We use these lean measurement tools in our model and integrate them in the field of RPA.

After two literature processing iterations we have enough output to create theory grounded measurements for each criteria. These will be elaborated in chapter 4 to create an understanding of the measurement; this will contribute to the satisfaction of the requirement KQ3.

3.3. RPA and Process Mining

A new literature review iteration is performed to answer KQ4 – "How can process mining be used to support the assessment?". Here, our aim is to find out if process mining can be used during the assessment of processes. It is important, according to our requirement, that process mining can be implemented in such a way that it does not become mandatory. We use a combination of all search keys to review papers on the combination of process mining and RPA. We only focused on the process mining combinations when it comes to RPA assessment. Mentions of process mining in other parts of the implementation process are out of scope.

Process mining aims to discover, conformance check and enhance real processes by extracting knowledge from event logs readily available in todays information systems [61]. The starting point for process mining is the event logs, these log files refer to activities in the information system [62]. The logfiles show information about the activities such as, the time stamp (i.e., when the activity took place), activity name, the initiator or executer of the activity, and data elements (i.e., product size, order number, etc.) [61], [62]. Unlike hand made process models with Business Process Management (BPM) techniques, process mining is based on facts. The log files show the actual use and process flows within the information system, unlike BPM, where a great part of the modeling is done based on human knowledge and experience [62].

Collaborations between RPA and process mining vendors are emerging. Vendors like UiPath and Celonis collaborated their RPA and process mining tools in order to select processes with process mining and automate them using RPA [5], [11]. Studies also mention that process mining and RPA can be a very viable combination [1], [11], [18], [42]. Especially for the process discovery phase, where processes are assessed on RPA suitability. Process mining can give real results and fact based documentation to base the assessment and implementation upon, rather than existing and often old documentation [42].

Besides mentioning the RPA and process mining combination, some researchers have also used a combination of the two with great success. Jimenez-Ramirez et. el. [42]. Showed in his research that by implementing process mining in the early process discovery phase of an RPA project, a lot more process flows where found than in traditional process discovery methods. The results show that by using process mining a much greater variety of paths – 30% more than with the existing documentation – was discovered. Although they didn't specifically measure the time it took to create the models, discovering the processes with process mining took a couple of hours, compared to a couple of days or even weeks with the traditional method. These same type of results are also found in other research where process mining was used to find additional undocumented process flows as input for RPA implementation [18].

Besides process discovery – which is interesting for the standardization criteria – process mining is also used in combination with RPA process assessment. Here, RPA process criteria are measured via log file data using process mining. Insights needed to judge a process on its RPA suitability for short term financial gains were found by the use of process mining. J. Wanner et. al. [20] shows how he uses process mining techniques to find the exact frequency, standardization, error rate, and execution time of a process. The research does not compare these results with the results of human analysis to these numbers. However, when looking at other research, it is likely that the information was gathered faster and more precise with the help of process mining than human would do.

Goris et al. [10] found that process mining is best used as a supportive technology in process assessment for RPA. Here, he found that the best information was gathered using a combination of traditional process assessment by humans with additional information gathered from process mining. This supports our statement that process mining should not be mandatory but does create additional information that can improve the assessment [10].

Concluding this literature review iteration on KQ4, we found that it is possible to use process mining in the RPA assessment process. Based on these results, we find that users of the assessment model can use process mining when in process discovery or when filling the model with data. This will help to spot any new or undocumented process flows and increase the over all reliability of the data and assessment model. Including process mining into the assessment of process will increase the reliability of the assessment and most likely make it less time consuming. It will also help to provide the assessor with sufficient information about the process to make a better assessment of the process. Processes can still be assessed without process mining, research shows that when process mining is used, there are additional benefits found during the assessment.

We will use the gathered information found in the literature review iteration on KQ4 in the design phase. Here, we will design a non-mandatory process mining implementation in the model. This way, we can provide the assessor with the benefits process mining can have on RPA process assessment if this technology is available for them. The main focus of the model will however not change, this will still be developed in a way that process mining stays as an additional tool in order to meet our goal of being applicable in all scenario’s.

3.4. Knowledge questions conclusion

Reflecting on the start of this chapter, we performed a literature review to answer the created knowledge questions. During this literature review, we found an answer to all knowledge questions.

KQ1 – What criteria makes a process suitable for RPA?
During the literature review we found that multiple studies created RPA criteria for process assessment. By combining these criteria and definitions, we created a list of criteria that are suitable for RPA process assessment. This list will be used as input for the design phase and will also be used as the main pillar for the assessment model. The design phase will extend on the gained knowledge from the literature review and create a model based on the found criteria and definitions.

KQ2 – What criteria can be used to assess a process on its business goal contribution using RPA?
Together with the literature review of knowledge question 1, this knowledge question could also be answered via the literature review iterations. First, we found that the assessment criteria can be divided in two main types: essential and business. Here, found that most criteria mentioned in literature are actually business criteria. These criteria are assessable process criteria RPA implementation can have a positive impact upon. We divided the found criteria based on these types and will use this during the design of the artifact.

KQ3 – How can we measure a process on RPA criteria?
During the literature review, we found that most of the criteria had related measurement options. Some of the found criteria are mentioned as important for RPA process assessment but did not include any specific measurement options. We started with a review of the used and proposed measures per criteria. Because we could not find measurement options for all criteria, we extend the research to other field of studies and found measurement options. At the end, we gathered enough information from the literature review to be able to combine all found measurement options and create one measurement per criteria during the design phase using the literature review findings as input.

KQ4 – How can process mining be used to support the assessment?
The literature review shows that process mining has been used multiple times with RPA. This has been done throughout multiple parts of the RPA implementation lifecycle. For us, the use of process mining during the process assessment was most interesting. Here we found that process mining can be used during the assessment. The results show that using process mining can:

- Decrease the amount of time it takes to assess a process
- Improve assessment by using facts based on data
- Increase process knowledge due to data insights

Now that we understand that process mining can be used to support the assessment process, we will incorporate it into the artifact. In the design phase we will create a way to implement process mining in a non-mandatory way so that businesses that have access to it can benefit from it, but businesses who don’t, can still use the assessment model. Process mining is known for its ability to provide fact based data and improve the process assessment. However, is has not yet been validated in comparison to a human employee. This is something we have to validate during the validation of the model in order to know if process mining really has added benefits over manual assessing a process.

4. Design

This chapter elaborated on the design phase of this thesis. As described by Wieringa et. al. the design phase aims to create an artifact based on the obstacles found in the problem context [31]. As described earlier, our solution to the gap in literature is the creation of a new process assessment model. During the design phase, we used all the information found in literature to create an artifact that in theory meets all requirements in order to fill the literature gap.

We identified that the following parts need to be designed in order to create an artifact that filles the gap in literature and also meets the requirements.

- Design a method to score a process on its RPA suitability and business goal contribution
- Design a way to integrate process mining without it being mandatory
- Design measurements for all criteria
- Design the model so that it is generic, but still viable for specific situations

We do this by using the information found in the literature review and so creating an artifact based upon this acquired information. This chapter will be followed by the validation chapter, where we test the designed artifact in its knowledge context and validate if the design meets its requirements in a real-life test case.

In this chapter we start by explaining how the different types of criteria play a role during the process assessment. Here we elaborate on the differences between them and explain how they will be support process criteria assessment. Followed by this, we show our design for process scoring. This section explains the chosen scoring mechanism for the assessment model and explain the inner workings of the assessment model weighted scoring.

The following design step is about the optional process mining addition to the model. Here we explain the voluntary incorporation of process mining to the model and how business can make use of the found benefits during the process assessment. Now that the base of the artifact is formed, we elaborate on all criteria measurements, which form the core of the assessment model. In this chapter we show the designed measurement options for all criteria with their respective scoring scale. Finally, we show our designed workflow which elaborates all the designed step the stakeholders will use to complete the process assessment, followed by a review of the requirements in relation to the designed artifact.

By basing the artifact on the results of the literature review, we know that in the model consists of proven components and methods. Because these components have not been put together before and have only been tested individually and because we had to adapt some parts for the model, we can not yet say with certainty that the design will actually work. To validate this, the follow-up chapter will consist of a case study, in which the designed artifact will be tested in a real-life problem context.

4.1. Measurement per criteria type

We distinguish two types of assessment criteria: essential criteria and business criteria. Both criteria serve different purposes during the assessment, the essential criteria are created to assess a process on the ability to implement RPA and the business criteria assess a process on the potential added value of RPA implementation. The essential criteria are obligated for a process to have, otherwise RPA cannot be implemented, business criteria are not.

The goal of the assessment is to see if a process is suited for RPA and to what extend the implementation of it will add value to the business goals. Due to the dependency of a process on the essential criteria, we decided to split the assessment in two iterations. A separate iteration for the assessment on essential criteria and a separate iteration on the assessment of business criteria. Splitting the two criteria types has some major benefits over an assessment that is done in one iteration consisting of both essential and business criteria.

By first assessing a process on the essential criteria, the assessor knows at the end of the first iteration if a process is either suitable or unsuitable for RPA implementation. If a process turns out to be unsuitable, the assessment on essential criteria saved the assessor time by not having to assess the process on its business criteria. If a process is suitable, the assessor can invest its time in measuring to what extend the process is suitable and adds value towards the business goals via the assessment on business criteria. The split in iteration filters out processes that are not suitable for RPA implementation using a shorter and focused iteration. Making sure that no time is waste on assessing a process on business criteria that might not even be suitable for RPA implementation.

The first iteration – assessing on essential criteria – is based around filtering out the processes that are unsuitable for RPA implementation. Based on the literature review and measurement scales, we found that this can be done using the Standardization, Rule based, Digitally available data, Data structure, and Maturity criteria. Each of these criteria can deem a process unsuitable for RPA implementation.

The first iteration is not designed to assess a process on to what extend it contribute towards the business goals, but rather focusses on filtering unsuitable candidates. We therefore only assess the process on the extreme limits that can make a process unsuitable for RPA implementation during the first iteration. This will be done via 1 main question per criteria. In order for a process to pass the first iteration, all questions must be answered with “yes”. If this is not the case and the process fails one or more essential criteria, it is deemed unsuitable for RPA.

If a process passes all essential criteria, the business criteria will be assessed in the second assessing iteration. Some essential criteria will not be measured again in the business criteria iteration, because there is no need to quantify the criteria. Others might return for quantification and so help to better assess a process on the business goal contribution.

The assessment on business criteria will be done via the measurement options designed in chapter 4.4 and then translated to respective scoring scales. Because no unsuitable processes are allowed to continue to the second iteration, all processes that are assessed on their business criteria are therefore able to be automated using RPA. The goal of the second iteration is to filter to what extend the RPA implementation of these processes will add value towards the business goals. In order to do this, the assessor needs to precisely complete the measurements and combine them with weights. This way, the business criteria measurements will show the assessor a final process score that indicates the added value of RPA implementation for that specific process.

4.2. Assessment scoring

Each criteria is scored in its own specific way based on the findings in the knowledge context. This means that not all scores are equally divided and have a wide range of measurement outcome. With the standardization measurement always below five and the frequency criteria possibly in the hundreds if not thousands. Scoring the criteria and processes requires a uniform scoring model, so that all criteria scores can be combined to form one process score which can then be used to compare processes and draw conclusions.

By scoring the processes, the model will create a clear understanding of the contribution of RPA in a process towards the business goals. This coincides with requirements three of the artifact: “The artifact shows what processes are suitable for RPA”. By implementing a total score for all processes, the assessor can see what process are best suitable for the business goals and which processes are less suitable.

For the total process scoring, we will be using an interval scale [63], [64]. All measured criteria will individually be grouped in interval scales and when combined result in a final process score. All criteria will be scored individually but will be combined to create the final process score.

The interval scales will be based on findings in the knowledge context. When not available, we will create our own interval scale based on best estimates or insights from other research fields that have similar measurement criteria. All interval scales will have five steps.

The intervals will be ranked non-dichotomous e.g., using a range. The ranks are based on the value measurement theory [65]. This theory assumes that the preferences are preferred over one another. In this case, a score of 2 is preferred over 1 (2 > 1), 3 over 2 but also over 1 (3 > 2 and 3 > 1), and so on [65], [66]. This suits the goal of this model, since businesses are looking to assess a process on the best contribution towards the business goals and therefore benefit by a scoring mechanism that provides a clear overview of the best automatization option.

The total process scale is based on the Likert scale which also uses a one to five scoring system. This way, each criteria can be measured in its own specific way but can still be scored using one unified method. Making it able to create a unified process score out of criteria with different measurements.

We choose to use a five-point scale for both the individual scales and the total process scale. This is because the assessment model will primarily be used to support the early stages of RPA implementation processes. Whilst it can be used later in the process, when more details are available, we believe that the main purpose of the model is to get an idea of the process’s suitability for RPA.

By using a five-point scale, the intervals are big enough to leave room for the necessary interpretation in the beginning stages of the implementation (where a part of the assessment is based on assumptions of the future implementation results) but does still give enough room to use more precise information during further phases of the implementation. We believe that using a 3-point scale will not provide the assessor with enough detail to carefully assess the process, where 10 interval steps would be too precise in the earlier states of the implementation process.

One of the goals of this assessment model is that it can be used in every industry, company, and situation but should also be able to support business objectives. We aim to achieve this combination of generalization and specific business objectives into one model via the implementation of weights.

The criteria used in this model are known criteria for RPA implementation, or criteria that support the best possible improvement potential i.e., rule based is essential for RPA implementation, but employee satisfaction can also be improved by RPA implementation when low. These business criteria are suited for business specific tweaking of the model toward certain objectives since they are not essential for RPA implementation and therefore benefit the realization of business goals.

One of the goals is to create a model that can be used in all scenarios. However, not all businesses implement RPA for the same reasons. Some businesses might want to improve the process' employee satisfaction, whilst other want to create more transparency and customer satisfaction into their processes. In order for the model to be relevant and useful in all these scenario's, weights are implemented.

Adding weights to the model is proposed by multiple researches on RPA process assessment [6], [11], [20], [26], [44]. The additions of weights in an assessment model can help to adjust the importance of a criteria. By increasing the weight of the criteria, the score will become more important than that of a criteria with a lower weight. This way, a company can adapt the model to its specific situation.

In the assessment model, weights will be given to all business criteria. The essential criteria will not be measured using weights. This is because all essential criteria are mandatory and thus equally important for RPA. The business criteria on the other hand help businesses to decide the added value towards their business goals and can therefore be adjusted accordingly.

The business criteria consist of 15 measurable criteria that – depending on the business goals – are not equally distributed in every situation based on the business goal importance. We choose to give each criteria a weight shown as a part of the total process weight. This total weight for every process is 1, meaning that 1 needs to be distributed over all criteria. When equally distributed, each criteria will have a weight of 0,0667[1]. This would translate to all business criteria being similarly important to the company. This can be used as the neutral position of the weights.

The assessor can – based on the business goals – increase the weight on criteria that are important to the company and contribute to the business goals. Increasing a criteria's weight means that another criteria's weight needs to come down. It is essential that the combined weights of all criteria are always equal to 1, otherwise the assessment will not be valid.

The final score is based on the combined value of all individual criteria scores multiplied by their respected weights. All individual scores are between 1 and 5, together with a combined weight of 1, the final score will always be between 1 and 5 as well.

Because all processes are suitable for RPA implementation – they pass the essential criteria iteration – the results are an indicator of which process suits the business goals best. The higher the final score, the better RPA will contribute to the business goals for that process. Processes that score close to 1 are still suitable options for business to implement RPA in, but they are less likely to contribute to the business goals represented in the weights as processes with a score closer to five.

By using weighted scores in the model, we ensure that a generic assessment model for RPA can be used in any business situation. By increasing or decreasing the weights of the business criteria, businesses are able to tailor fit the model to their business goals. The total process score helps to easily spot differences between processes and decide whether or not to implement a process.

4.3. Process mining

The literature review on process mining shows that its use during the assessment of processes can give great benefits on throughput time, assessment quality and process knowledge. For this reason,

[1] Equal weights = (1/15)

we concluded that process mining can be used during RPA process suitability assessment. Our models' goal is also to be suitable for all businesses and thus we cannot make process mining a mandatory option for RPA process assessment. This is because not all businesses have process mining available to them.

This chapter will describe how these process mining benefits can be obtained by using process mining during the assessment. We will design an artifact that supports the use of process mining during assessment but does not make it a mandatory requirement for the artifacts use. This way, businesses that have process mining available can profit from the benefits, but businesses that do not have process mining available can still use the assessment model.

To incorporate process mining into the assessment tool we will design a possible use case for process mining in each of the different assessment steps. This way we design a way to benefit from the process mining potential during implementation. Steps that are not mentioned do not have optional process mining implementation according to current literature.

Initial assessment of RPA candidate processes
Process mining is known to find a wider variety of used application and process paths than existing documentation [18], [42]. Process mining is based on facts and real interaction with a process and the application. Using process mining in this assessment step can thus result in a better initial assessment than an assessment based on existing documentation. We suggest using process mining in this step to see all the different flows that are being used and compare those to the existing documentation. This will most likely result in new flows that can be assessed or create a better representation than the documentation of the process.

Assess candidate processes on essential criteria
This is the first iteration of the assessment, where processes are assessed on their RPA suitability. In this step it is important to understand the process in order to fill the assessment model with the right values. Here, the process will be assessed on the five essential criteria found in literature. Most of the criteria cannot be checked using process mining and must come from process knowledge and understanding: rule based, digitally available, data structure, and maturity.

Standardization however can be assessed with the help of process mining. Like with the previous step, process mining can give a better representation of the current situation than documentation can. This can benefit the assessment on standardization as well. Assessors can use process mining to exactly know the amount of existing exception flows to the assessed process. This way, the assessor knows for a fact that there are or aren't more then five exception flows. Where with assessment based on documentation, this might not be the case. For this step, the use of process mining will increase the assessment quality and reduce the change of a faulty assessment on the standardization criteria.

Assess candidate processes on business criteria
Like with the essential criteria assessment, process mining can give substantial benefits when it comes to criteria assessment over documentation or human process knowledge. We therefore advise businesses to use process mining for as many criteria as possible. When process mining is being used, the assessment will be completely fact based. This will result in a higher quality assessment and thus a better representation of the RPA implementation impact. Besides this, the assessment will be much faster when using process mining compared to manual assessment. For a lot of criteria, the assessor must track activities over a one-week period. This can be very labor intensive and will take at least one week throughput time to complete the second iteration. With process mining, one week of data can be extracted from the process and analyzed using the process

mining methods. This way, the assessor does not need to manually track the criteria but can simply analyze the data and complete the assessment. This will approximately reduce the assessment time from one week to one day whilst also increasing the validity.

Currently, research has shown that the following criteria can be measured using process mining: Standardization, Frequency, Time saving, and Availability. Efficiency can be calculated using process mining data insights. Errors can also be spotted using process mining; however, it will most likely not be known as a human error and therefore the assessor needs to analyze the found errors to see if they are human errors or not.

By using process mining on all of these business criteria the assessor will not only decrease its assessing time, but also increase the precision of the assessment. Businesses that cannot use process mining will need to track the assessment criteria by hand and can so still use the model. However, it is plausible that the manual assessment of a process will be less accurate and have a longer throughput time.

When creating the assessment criteria measurements, we make sure that it is possible to measure all criteria without the need of process mining. During the validation of the model, we will validate the impact of process mining on the above mentioned criteria and compare the results to a manual process assessment in order to better understand its benefits and impact on the assessment.

4.4. Measurements per criteria

This chapter will elaborate on the measurement methods chosen for each assessment criteria. All criteria mentioned in previous chapters will be mentioned in relation to their chosen measurement option, interval scales, and how these will be used in the assessment model. The measurements per criteria will create an explanation and approach to the assessment of the earlier stated criteria. By connecting measurements to these criteria, we will complete requirements one and two – being able to assess a process on RPA criteria – and form a base for the fulfillment of requirement three which will be completed in combination with the other design chapters.

Standardization

All sources showed that the standardization of a process can be measured by the number of exceptions to the standard flow. Exceptions to a process' standard flow indicate a low level of standardization. As stated earlier, these exceptions can take a lot of work to automate into RPA and process with less exceptions are therefor better RPA candidates [11], [16], [20], [26], [46].

The standardization will be measured by counting the number of exceptions to the standard flow. A process will always have a main process flow, the flow that most cases follow. Most of the time, this will be the flow a company likes to automate using RPA. However, each candidate process will likely have some exceptions to this main process flow.

Standardization has been qualified as an essential and business criteria according to the literature review. This is because processes with a high number of exceptions are deemed unsuitable for RPA, due to the amount of work, time, and precision that is needed to program these exceptions into an RPA bot.

Because there is no research available on the exact numbers of standardization, we estimated it to be unsuitable when a process has more than five exceptions to the standard flow. The essential criteria will therefore be measured via the question: *"Does the process has less than five exceptions?"*. When answered with "no", the process is unsuitable and cannot continue to the second iteration. Because we estimated this number, we encourage future research on this topic.

If a process has less then five exceptions and meets all other essential criteria, it will continue to the second iteration. Here, standardization will be measured again as a business criteria. We know that a process is more suited for RPA when it has low amounts of exceptions. Business can therefore prioritize this criteria if fast implementation is desired. Research also suggest starting with processes that have low amounts of exceptions when new to RPA [9], [10].

Because of the lack of research, we estimated the scoring scale for the business assessment of standardization. This is based on the cut-off we selected for the essential measurement. Like mentioned before, we encourage future research on this topic. The scoring will be as followed:

1. 5 exceptions to the standard flow
2. 4 exceptions to the standard flow
3. 3 exceptions to the standard flow
4. 2 exceptions to the standard flow
5. 0 - 1 exception to the standard flow

Rule based

For RPA, one of the most important factors is that the process must be possible to be defined in business rules. Meaning that the process follows a defined set of rules and thus can be automated, as defined in our literature review chapter. Without these rules, processes often require more creative skills which are very hard to automate using RPA technology. Being able to judge if a process is rule based or not is therefore a key factor when it comes to process suitability assessment [16]–[18], [34], [44], [45].

All sources described the importance of rule based processes, this is such an important factor that processes that are not rule based shouldn't even be considered to be automated using RPA [16], [17]. Processes that are being assessed will be assessed on this criteria by answering the following question: *"Is it possible to define the process by business rules?"*

This answer requires the assessor to have enough knowledge about the process to know if it is possible to fully define it by business rules. When it is, it needs to be answered with "*Yes*" telling us that the process is suited for RPA. When answered with "*No*" the process does not meet the essential criteria and will automatically fail the assessment. Answering *"No"* indicates a process that requires creative thinking and is therefore not rule based. This will result in the process not being assessed in the second assessment iteration.

We do not incorporate any scoring scale for the rule-based criteria. This is because RPA must always be connected to business rules in order to work, meaning that anything that is not rule based will automatically fail the assessment. The criteria will therefore only be used in the first assessment iteration and will not be used in the second iteration of assessment.

Frequency

Frequency will be measured by counting the number of transactions per day. This indicates how often a process is being used each day. Processes with high numbers of frequency are good RPA candidates. They are deemed to be better RPA candidates than processes with lower levels of frequency. The assessment model will therefore preference a process with higher frequency over a process with lower frequency [11], [20], [26], [35], [44].

We measure the daily frequency – DFR_{pc} – as the count of cases (*c*) processed in the process (*p*) per day.

$$DFR_{pc} = \sum c_p \tag{1}$$

In order to filter out any daily spikes, the frequency is measured as an average per day over a one-week period based on the amount of business days. We then divide the sum of all measured DFR_{pc} as $\sum DFR_{pci}$ to the i^{th} term, where *N* equals the number of measurement days. Resulting in the average daily frequency of the process: FR_{pc}

$$FR_{pc} = \frac{\sum DFR_{pci}}{N} \tag{2}$$

We know that RPA relevance is most present in the bottom 20% of case frequency, covered by around 80% of case types [5]. We also know that there is a frequency cut-off where RPA implementation is not feasible from an ROI point of view [5]. This is shown in figure 9. We will not exclude the bottom side of figure 9 from the assessment, because a business can choose to implement RPA based on a variety of goals. When excluding the bottom range of the frequency, some processes might not be assessable.

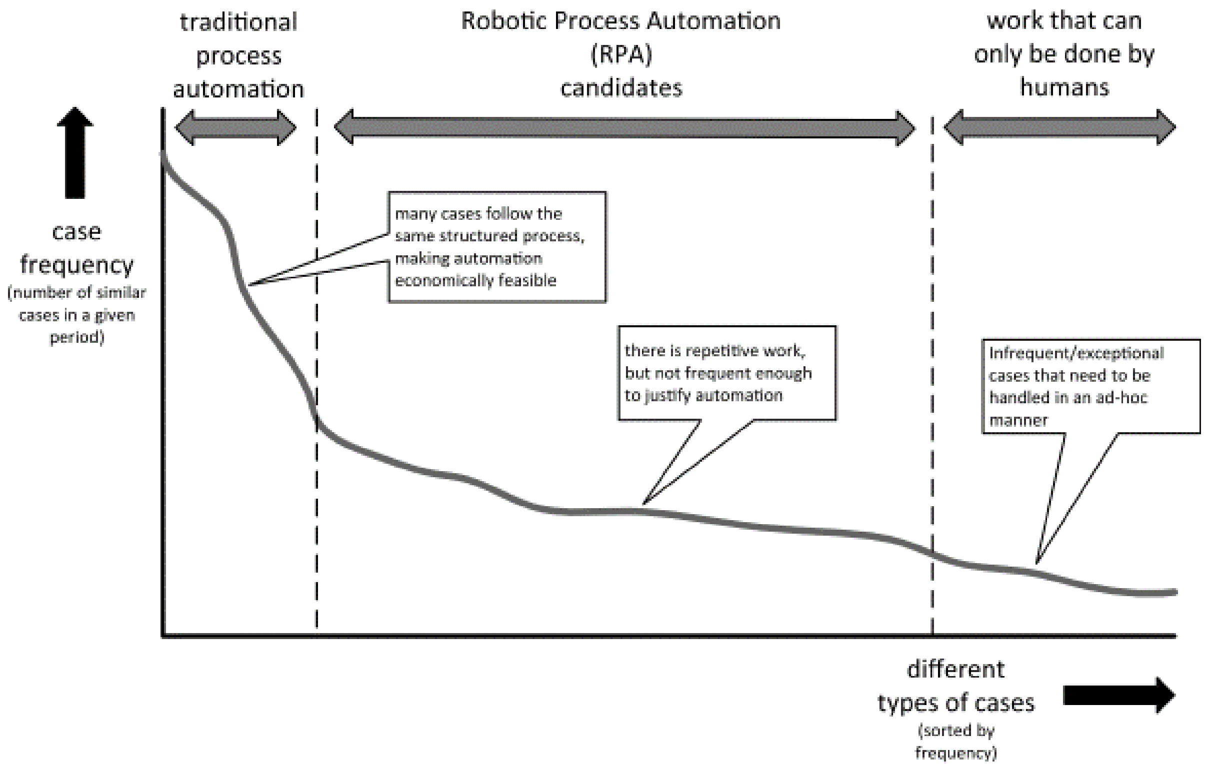


Figure 9 - RPA relevance by case frequency

In order to determine the frequency scoring scale, we need to find a certain frequency level that represents the top frequency level for RPA relevance – the bottom 20% of case frequency. Because there are no exact number available on this topic, we tried to substantiate our scoring scale, by analyzing open-source real-life datasets.

By analyzing these real-life datasets, we can get an idea of the daily case frequency per process that was available in the datasets. We combined this with datasets from applications used in the supporting company of this thesis. All datasets are from completely different departments in the company with different processing types in order to get the best possible representation of daily frequency.

During these analysis, we excluded the top 80% of case frequency to represent the top cut-off as described by Aalst et. al. [5]. Unlike the statement of Aals et. al., in most cases, this didn't represent 20% of the case types. The case types that covered around 80% of the frequency was ranging between 1 and 10 percent of all case types. Full results of the datasets can be found in appendix 9.4 – Case frequency analysis results.

Here, we can see that the FR_{pc} has a wide range depending on the process and dataset. The complete range of the bottom 20% of case types based on frequency is between 20 and 1974 average daily cases.

We will use this range for our scoring model scale. The mean of the FR_{pc} results is 997[2] with the average being 673[3]. We decided to create a range for the scoring scale where the average of the FR_{pc} results would fall into the average score 3. This results in the following scale:

1. FR_{pc} = 0 – 250
2. FR_{pc} = 250 – 500
3. FR_{pc} = 500 – 750
4. FR_{pc} = 750 – 1000
5. FR_{pc} = > 1000

Because this scale is based on a small research, it might not be representative in other scenario's using other datasets. We therefore encourage future research on this topic. During the validation of the model, we will also check the outcome of the scoring scale.

Number of involved systems

All sources agreed that the number of involved systems should be measured by counting all connected systems used in order to complete the process. When more systems are required to complete the process, RPA will be a suitable solution [11], [16], [26], [27], [35], [40]. For this criteria, more required systems means that the process it more suited for RPA. As found in the literature review, RPA will have the most impact on these processes due to the reduction of error and speed they can operate between applications.

$$NIS_p = \sum NIS_p \qquad (3)$$

Processes with multiple involved systems are more suited for RPA. We therefore create the follow scoring scale. There is no research available on the exact relation between the exact number of involved systems and RPA suitability. This scale is therefore estimated and will need future research.

1. 1 involved system
2. 2 involved systems
3. 3 involved systems
4. 4 involved systems
5. 5 or more involved systems

[2] ((20 + 1974)/2)
[3] ((20+95+1974+767+509)/5)

Data quality

The data quality for RPA depends on four main factors. Two of those – digitally available data and structured data – are essential for RPA. The other two are business criteria, with consistency being an important factor for RPA stability and documentation for the implementation process of RPA. When researching data quality measurements, sources state that the data must be assessed on four criteria [7], [11], [16], [26], [27].

The data must be digitally available

This can be checked by assessing if all data sources in the process are digitally available. When this is the case, the assessor will fill in "Yes". If the data isn't completely digitally available, the assessor will fill in "No". Since this is an essential criteria for RPA implementation, "No" will result in a negative assessment for the process deeming it unsuited for RPA implementation. This criteria will not be repeated in the second assessing iteration. Processes that have a "No" here won't make it towards the second iteration, leaving only processes in the second iteration that have digital data available. This is key, because RPA in unable to work with information that is not digital.

Consistent, doesn't contain 'surprising' values and undefined datatypes

The data must be checked on 'surprising values' and undefined datatypes. Errors in the data can result in error in the bot. These errors will then need to be resolved by human interaction or via exception flows [43]. It is therefore best to have a high level of consistency in data. Processes with higher levels of consistency will result in less errors and so create a more stable RPA experience. Inconsistencies can be: NULL-values, and undefined datatypes. The consistency of the dataset can be measured by evaluating the amount of inconsistencies compared to the total dataset [11], [46], [50].

The data consistency op the process (p) DC_p will be calculated by the dividing the total amount of inconsistencies found in the dataset by the total amount of entries in the dataset. (4)

$$DC_p = \frac{\sum Inconsistancies\ in\ the\ dataset}{\sum Database\ rows}\ x\ 100\% \qquad (4)$$

In order to score the criteria, we will create a range for DC_p. We know that data inconsistencies will lead to errors and require interaction with the bot. Reducing the efficiency of the RPA bot with every data inconsistency. Hence, RPA can best be implemented on processes with low levels of DC_p.

Because there is no research and data on the relation of inconsistency and RPA efficiency, we will create our own scoring scale. For this, we will use the pareto principle as a base line. Assuming that around 80 percent of the data meets the consistency rules documented and programmed in the RPA bot. From here, we build the scoring scale up to 100% - a perfect dataset without inconsistency. This will result in the following scale:

1. DC_p = < 80 percent
2. DC_p = 80 – 85 percent
3. DC_p = 85 – 90 percent
4. DC_p = 90 – 95 percent
5. DC_p = > 95 percent

Because this scale is estimated. We encourage more research on this topic.

Data structure must match the supported RPA data structure
RPA bots can often only support unstructured data. However, some newer technology developments in RPA bots make it able to support unstructured data as well [7], [67]. In order for the RPA bot to work, it will be important that the data structure it has to work with can be supported by the bot. This must be verified by assessing the bots input data and structure requirements. If the structure meets the requirements of the RPA bot, RPA can be implemented [6], [16], [26], [27], [43], [46], [51], [52].

This will be assessed using a "Yes" – meaning that the structure is equal to the supported structure – or "No" – meaning that the structure is not supported by the bot. Since the data structure is categorized as an essential criteria, "No" will result in the processes not being suitable for RPA implementation. This will, like with the digital availability, result in the criteria not returning in the second iteration of the model.

Data must be carefully defined
When the data is defined, RPA implementation can become easier. There are no additional checks or investigations required during the RPA implementation because the documentation states the necessary information [6], [50], [52]. Processes with good, up-to-date, and detailed documentation are better RPA candidates and will result in a better and most likely faster implementation experience.

To score this criteria, we will be using a Likert scale. This will score the criteria from 1 to 5 based on the usefulness of the documentation. The assessor will assess the current process documentation on its usefulness during the RPA implementation process. He can do this by reviewing, for example, the age of the documentation, level of detail, and even test the documentation with the help of the actual dataset. Based on this assessment the assessor needs to answer a question using the provided scoring scale. "*The documentation provides sufficient information about the process to use during the RPA implementation process*":

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

Data quality scoring per iteration
In the first iteration the essential data criteria will be measured. Both need to be answered with "Yes", otherwise the process is not suited for RPA implementation.

For the second iteration, the business criteria of data quality will be assessed – documentation and consistency. Here, both criteria will be scored using a scale from on to five. To conclude this to one final score for data quality, we will merge the two business scores into one score. For this, we will use formula (5).

$$Business\ data\ quality\ score = \frac{(score\ 'documentation' + score\ 'consistency')}{2} \tag{5}$$

Maturity

The maturity of a process in relation to RPA is based on the number of planned changes in the near future, as also earlier stated in our definition. This means that processes with planned changes in the near future are highly likely not to be feasible for RPA implementation and therefore not suited. This is why the maturity has been classified as an essential criteria. However, when maturity is low it becomes a business criteria businesses can use to assess a process upon in order to aim for RPA stability after implementation.

The maturity will be measured by investigating if there are changes planned for the process in the future. The further away the changes are planned, the longer the RPA implementation will be used without the need of adjustments. Because RPA bots are programmed to follow precise inputs and rules, changes in the process will result in a change in the bot resulting in more cost, downtime and other implementation activities [11], [17], [26]. Therefore, the sooner a change to the process is planned, the less it will be suited for RPA implementation.

The assessment of potential processes will take place in two steps. The first step is to assess the processes on maturity as the essential criteria. In order to judge if a process is suited for RPA implementation, we tie the planned change horizon to the scale we know from the return on investment. The return on investment on RPA projects is often reached between three to six months and is typically less then a year [40], [53]. For the first step, we will therefore assume that planned changes to the process within a three-month period will not be suited for RPA implementation. This is because it will be likely that the cost won't way up to the potential benefits of the implementation due to the fast required change in the RPA bot. Three months is also the estimated time it takes to implement an RPA bot on more complex processes [68]. When changes are planned within three months, it is better to wait for the change to be implemented and then start with the implementation of RPA.

For the second iteration, processes will be scored on its duration without planned changes. Processes with long horizons of no planned changes will be better RPA candidates. We advise interviewing stakeholders and process owners in order to find out about the planned changes to the process and use these results in the assessment model. Maturity can be given a higher priority if businesses like to have a stable RPA bot processing the work without the need of re-work and adjustments due to planned changes to the process.

There is no direct research available on the exact relation between planned changes and RPA suitability, we therefore estimate a scale based on the current knowledge context. We start the scale where the first assessment iteration stopped, at three months. We then create intervals based on this three-month period. Resulting in a scale that is divided in blocks of three months. We advise future research on the exact relation of maturity on RPA assessment.

1. Planned changes within 3 – 6 months
2. Planned changes within 7 – 9 months
3. Planned changes within 10 – 12 months
4. Planned changes within 13 – 15 months
5. Planned changes past 15 months or no planned changes

Human error

This criteria will be measured by counting the number of cases that result in an error due to human interaction. Errors that are created by for example, missing data, should not be counted as error for this criteria. It is important to understand the narrative of the error and know that it has been caused by human interaction with the process. Errors in the process that are not caused by human interaction are unlikely to be reduced after RPA implementation. The known benefit of RPA is that it has close to no errors when processing cases. Unlike human employees who make mistakes more easily due to lack of concentration, work pressure or other external factors. If a business has the goal to reduce the number of errors in the process with RPA implementation, it is key that these current errors are due to human interaction. If this is not the case, RPA implementation will likely not reduce the number of errors in the process.

RPA will, due to it following a set of rules, reduce the number of errors and always follow the process as programmed and defined. A process that scores a high number of human errors therefore also scores good for RPA suitability, since the improvement potential is high [11], [16], [26], [27], [35].

To equate this with the other measurements, we advise businesses to count the average number of cases with a human error per day based on a one-week business period. Working with an average will filter out any daily peaks that might occur when choosing a – for example one day – timeframe.

The amount of process human errors – HE – needs to be tracked daily. This means that the assessor needs to track the HE over multiple days and create an average per day. This will be done via formula (6) where $\overline{x}_{HE}$ is the average number of cases including human error. This is based on the sum of all measured human errors $\sum HE$ of all days (*d*), divided by *N*: number of measurement days. Creating the average amount of human errors per day of the process (*p*).

$$\overline{x}_{HE_p} = \frac{\sum HE_d}{N} \tag{6}$$

Anagnoste et.al. [23] not only mentions the number of human errors, but also the error rate. The error rate is based on the amount of errors cases measured against the total amount of cases – known as the frequency [69]. Using an error rate will help the assessors to better understand and compare all process errors. Processes with high human error rates are good RPA candidates, these will have more potential benefits from the implementation as found during the literature review. The error rate of the process ER_p will be calculated by dividing the $\overline{x}_{HE_p}$ with the FR_{pc} , resulting in the daily human error rate of a process (7).

$$ER_p = \frac{\overline{x}_{HE_p}}{FR_{pc}} \times 100\% \tag{7}$$

The error rate will be used for the scoring scale. This way, the assessment model stays applicable for every process independent on its number of errors, but as a rate of the total frequency. The scoring scale for the error rate is based on an estimate and will need further future research in order to provide more insight on the exact relation of error rate and RPA suitability. Processes with high error rates are better suited for RPA, because these processes have the most potential to be improved by the implementation.

However, it is very unlikely that a process consists of up to 100% error rate. Because of this, we have to adjust the scoring scale keeping a maximum error rate in mind. For this, we use the pareto principle [70]. Assuming that the process has around 20 percent of its cases resulting in errors with 80 percent passing the process without errors. The scoring scale will be as followed:

1. $ER_p =$ 0 – 5 percent error rate
2. $ER_p =$ 5 – 10 percent error rate
3. $ER_p =$ 10 – 15 percent error rate
4. $ER_p =$ 15 – 20 percent error rate
5. $ER_p =$ > 20 percent error rate

Because this is an estimation and was deemed out of scope for this thesis, we encourage future research on this topic.

Return on investment

The most used return on investment formula shows the ratio of net benefits to cost [71]. This formula is also used to determine the RPA return on investment. Out of all sources that mentioned ROI in their papers, Lacity et. al., Sigurðardóttir et.al., and Wanner et.al. [9], [17], [20] showed this formula of benefits in relation to cost of RPA implementation. Formula (8) will also be used in our assessment model. We advise calculating the cost and benefits over a one-year period.

$$ROI = \frac{(Benefits\ of\ RPA - Cost\ of\ RPA)}{Cost\ of\ RPA}\ x\ 100\% \tag{8}$$

Benefits

The benefits of the ROI calculation are based on the reduction of FTE cost after RPA implementation. One of the main expected returns of RPA in businesses is time saving and FTE reduction [27]. The benefits of RPA are therefore measured in saved amount of FTE [11], [22], [23], [34], [40], [41], [53]. The cost of one RPA bot is often lower than those of an FTE. RPA bots can often do 70% more work than human employees and are between one third and one fifth of the price [11], [40], [53].

The amount of saved FTE needs to be expressed in money. It is therefore important to multiply the saved FTE with the cost of that employee, this equation will result in the benefits of RPA for the ROI formula.

Cost

The cost of RPA is based on the accumulative cost of both the process implementation of RPA and the license cost of the RPA bot(s). [9], [16], [23], [41] The license costs of the bot(s) need to be requested by the RPA supplier. The implementation cost consists of the programming cost of the RPA bot, the amount of time it takes to create all the necessary documentation, and also testing.

The ROI is often reached between three to six months and is typically less then a year [21], [40], [53]. Because of this insight, we can create a scoring scale for the ROI. This scale is based on the annual cost versus the annual benefits as also shown in formula (8).

1. < 0 percent — ROI more then a year
2. 0 – 50 percent — ROI between nine and twelve months
3. 50 – 100 percent — ROI between six and nine months
4. 100 – 300 percent — ROI between three and six months
5. > 300 percent — ROI under tree months

Employee satisfaction

A successful RPA implementation often results in increased employee satisfaction [7], [22], [26], [27]. This is because RPA will take over certain tasks of employees that are seen as tedious, repetitive, and not challenging causing a lower employee satisfaction and thus increasing the satisfaction after RPA implementation. The measurement of employee satisfaction is therefore often mentioned as the decrease of those repetitive and non value adding tasks after RPA implementation [2], [8], [9], [12], [31].

In order to find out the employee satisfaction of a certain process before RPA implementation, we will use ESI to measure the employee satisfaction directly from the employees that perform the process. The employee satisfaction will be based on the process attributes RPA can have an impact upon and potentially improve. This way, the assessor can find out if the current employee process satisfaction is low and if RPA implementation can increase this satisfaction by impacting repetitiveness, performing non value adding tasks, and reduction of boring tasks [2], [8], [9], [12], [31].

This will be focused on process and job characteristics RPA can have an impact upon. Measuring (dis-)satisfaction on characteristics RPA cannot have an impact upon might lead to false readings. These characteristics will most likely not change due to an RPA implementation, resulting in a result that is not relevant to RPA and will therefore not be useful during the assessment. For the same reason, the employee satisfaction should always be assessed based on the process that is in scope of RPA implementation and characteristics likely to be positively influenced by RPA implementation.

Because there are no RPA related customer satisfaction models, we have adapted one to fit the RPA characteristics. The employee satisfaction index (ESI) measures the employee satisfaction via a set of targeted questions about the job [72]. These questions can be used to either get a general impression of the employee satisfaction of that job, or to find the satisfaction on specific aspects of the work [72], [73].

Adapting the ESI questions for our assessment of employee satisfaction can provide the assessor with the process' employee satisfaction. The questions must be about RPA related criteria, in order to make sure that the implementation can have an effect on the employee satisfaction. According to [2], [8], [9], [12], [31] the questions should be about: repetitiveness, if the employee feels like he/ she is adding value with the task, and if the job is challenging enough. We also add a general satisfaction question to get an idea of the employee overall satisfaction on the process besides the RPA-related measurements in appendix 9.5. Employee satisfaction index – Example questions

Scoring the questions is done via the Likert scale [73], [74] where the answers of the questions are divided into 5 different forms: Strongly disagree, disagree, neutral, agree, strongly agree [75]. These all translate to certain scores, ranging from 1 to 5 from strongly disagree to strongly agree. These scores are then transformed into a final ESI score. Here, the total score of each employee is added and divided by the maximum possible score, resulting in the ESI. (9) The closer the Index's value is to 100, the higher the satisfaction. Because the ESI is based on criteria RPA implementation can have a positive impact upon, processes with lower ESI are better suited. The implementation of RPA in these processes is likely to increase the ESI.

$$ESI = \frac{\sum Employee\ satisfaction\ scores}{Maximum\ score}\ x\ 100 \tag{9}$$

The ESI scoring scale ranges from 0 to 100, like the possible outcomes of the ESI. To suit our chosen interval of 5, we created equal intervals. Processes with low ESI are better suited for RPA, meaning that a score of five represents a low ESI and thus has a lot of improvement potential after RPA implementation.

1. $ESI =$ 100 – 81 percent
2. $ESI =$ 80 – 61 percent
3. $ESI =$ 60 – 41 percent
4. $ESI =$ 40 – 21 percent
5. $ESI =$ 20 – 0 percent

Process quality

We found that process quality and quality in general are different for each process, company, and person. Because our aim of the assessment model is that it can be used in every industry, process, and company we aim to measure process quality in a way that suites the assessment model requirement. Most researched sources stated that RPA implementation can increase the process quality, often due to the reduction of errors [3], [9]–[11], [16], [22], [40]. We like to extend on this and measure process quality on all aspects RPA implementation can have an impact upon – all of our measurement criteria.

Multiple sources have stated that the use of weights in RPA assessment models can help assessors to show the perceived importance of a criteria [20], [26], [44]. Looking at our definition of process quality, using weights to show criteria importance can help the assessor to adjust the model to its needs. Our assessment model will therefore also include criteria weights. By increasing the weight of a criteria, the importance also increases. Meaning that criteria with high weights represent a higher value for the assessor. If RPA is able to improve on a high weight criteria, the process quality will increase.

The quality of the process won’t be measured using this model, the model can be adapted so that certain RPA aspects can be given more importance over others. Showing the areas that need to be improved most according to the assessors needs and goals. When implemented correctly, this will result in higher process quality after RPA implementation, due to the improvements RPA will have on the process’ most important aspects. The use and implementation of weights is discussed in chapter 4.2 – Assessment scoring

Time saving

Ten out of eleven sources agreed that this criteria should be measured by its turn around time (TAT). This is the time it takes to complete a process from start to end [7], [17], [76]. One source also mentioned that this criteria should be measured by saved time after RPA implementation [16].

The TAT will indicate how long it currently takes to perform the process. A high TAT indicates an inefficient, big or complicated process [20], [26], [44]. Processes with a high TAT are considered to be good RPA candidates, since these processes can often benefit the most of the time saving capabilities RPA can provide [3], [10], [11], [16], [20], [26], [27], [35], [40]. The goal of this criteria is to find the process with the biggest time saving potential.

The TAT will be measured via equation (10) following the formula representing the definition as mentioned in [7], [17], [76]. Here we measure TAT_{pc} as the Turn Around Time per case in the assessed process. Where ST_{pc} is the starting time of the case and ET_{pc} is the ending time of the case. Indices *p* defines the *process* with *c* being a specific *case* withing that process.

$$TAT_{pc} = ET_{pc} - ST_{pc} \tag{10}$$

In order to filter out any peaks in the process and equate the measurement with the other measurements in the assessment tool, we advise to use an average TAT measured over a one-week period equal to the amount of business days. Equation (11) measured $\overline{x}_{TAT_{pc}}$ as the average TAT per process (*p*) case (*c*) where TAT_{pci}: is the i^{th} term, divided by *N*: Number of variables over the measured period.

$$\overline{x}_{TAT_{pc}} = \frac{\sum TAT_{pci}}{N} \tag{11}$$

Currently, not al lot is known on the exact relation of turn around times and RPA suitability. It is therefore not possible to provide an exact scoring scale for the turn around time. In order to create a scale, we use publicly available datasets to estimate the scale. These datasets provide insight on the $\overline{x}_{TAT_{pc}}$ in practice. Here, we used the same combination of datasets as with frequency. For each dataset, the 3 process flows with the highest frequency were measured for $\overline{x}_{TAT_{pc}}$. The results are in appendix 9.6 - Turn around time dataset results.

Because the process average TAT can differ a lot per process, as shown in appendix 9.6 - Turn around time dataset results, we decided not to score based on this measurement alone. As suggested by [16] the scoring will be done based on the estimated saved time after RPA implementation.

Comparing just the duration of the process can lead to false conclusions. Processes that take, for example, 10,000 minutes to complete would be better RPA candidates than processes that take 1,000 minutes to complete. However, with any information on the estimated saved time after RPA implementation, the 1,000-minute process can be a better option due to it percentage wise saving more time. Besides that, it would be very hard to estimate any suitable interval scale for this criteria since a processes can have a very wide range TAT, as shown by the datasets.

We will not solely measure the average TAT, but also implement an estimated saved time after RPA implementation in our measurement for time saving. Processes with the highest estimated time saving potential will be better RPA candidates. Estimating the saved time per case can be done by analyzing the TAT on parts of the process RPA can have a positive impact upon and described in the literature review for time saving.

The assessor will start with the $\overline{x}_{TAT_{pc}}$ and estimates a potential time saving amount per case. Using formula (12), the assessor can calculate the time saving percentage (*TS*) per case (*c*): TS_c.

$$TS_c = \frac{Estimated\ saved\ time\ per\ case}{\overline{x}_{TAT_{pc}}}\ x\ 100\% \tag{12}$$

The scoring for the time saving will be done based on the outcome of TS_c. Processes with a high TS_c will be better RPA candidates, because they can save the most time after RPA implementation relative the process TAT. The scale has been equally divided in increments of 20 percent over five intervals.

1. $TS_c =$ < 20 percent
2. $TS_c =$ 20 – 40 percent
3. $TS_c =$ 41 – 60 percent
4. $TS_c =$ 61 – 80 percent
5. $TS_c =$ > 80 percent

Availability

All sources agreed that in order to measure the availability of a process, the potential extra hours the bot can operate in the process compared to a human FTE should be considered. RPA is known for its ability to work 24 hours a day and seven days a week [27], [40]. Processes that require more availability or have increased availability after RPA implementation are considered to be better RPA candidates.

In order to measure the availability gains of the RPA implementation, all sources mention assessing the process on its added availability as a result of RPA implementation compared to the current availability with human employees [3], [10], [13], [40]. Thus, more availability after RPA implementation means the process provides more added benefits then options with less extra availability.

According to Lamberton et. al. [53] it is important not to only focus on the RPA automated process, but also the surrounding activities. RPA will be dependent on the amount of work that it can handle. This might result in scenario's where the previous step in the process becomes the bottleneck and prevents RPA from increasing its availability of the process. This should be considered when assessing the added availability.

The increase of availability will be measured as a percentage of the current process availability on a daily basis. By comparing percentages instead of added availability in for example minutes, it will be easier to see what processes will perform better in this criteria when the assessor wants to compare certain processes on this criteria. The availability will be measured using the formula (13) for the increase in availability (AV) of process (p).

$$AV_p = \frac{Extra\ availability}{Current\ availability}\ x\ 100\% \tag{13}$$

Because there is no research available on availability results, we have estimated a scale based on the expected availability improvements. RPA is known for its ability to work 24/7, increasing the availability of a process to its maximum possible capacity. Assuming most processes are currently available during working hours, RPA will in most cases increase the process availability from 8 to 24 hours a day (*200%*). This will be used as our mean increased number e.g., score = 3. The increments of scoring will be done in ranges of 100 percent. This is an estimated scale; we therefore encourage future research on this scale.

1. $AV_p =$ 0 – 100 percent increase
2. $AV_p =$ 100 – 200 percent increase
3. $AV_p =$ 200 – 300 percent increase
4. $AV_p =$ 300 – 400 percent increase
5. $AV_p =$ > 400 percent increase

Efficiency

In lean, process cycle efficiency (PCE) is being used to measure the average time spend on value adding activities in a process (14) [77].

$$PCE = \frac{Total\ value\ adding\ time}{Total\ process\ time}\ x\ 100\% \tag{14}$$

This formula is being used to show the efficiency of a process. The outcome shows how much time in the process is being used to add value to the process. Processes with high PCE are considered to be more efficient than processes with low PCE outcomes. The processes with low PCE are considered to be good RPA candidates, since RPA in known to increase process efficiency after implementation.

In our assessment model we will use this PCE formula to calculate the efficiency of a process. In the lean literature, non value adding time can be found in any sort and form. If we use this same technique for the RPA assessment model, processes might be assessed as inefficient on parts of the process RPA implementation won't have an effect on. This can ultimately result in a process that is marked as inefficient, making it suitable for RPA implementation, but in reality, the RPA implementation won't have an impact on its inefficiency.

We therefore measure the non value adding time spend in the process via criteria RPA implementation can have an impact upon. This way, the assessment outcome of low efficiency can actually be countered by the RPA implementation. According to the available sources, lowering the amounts and duration of errors increases the efficiency after RPA implementation [11], [44], [77].

The averaged amount of time spend on the human errors will therefore be used as non value adding time and should be measured. For this, we will measure the time spend on the correction of a human error in the process over a one-week period. The same formula as the turn around time can be used for this, but this time for the TAT of correction of human errors. Each error case needs to be tracked over a one-week business period. Like with the other measurements, these daily measurements will be divided by the amount of measurement days, resulting in the $Average\ error\ TAT$.

The total processing time can be created with the already available and measured information. The total processing time can be created by multiplying the $\overline{x}_{TAT_{pc}}$ with the FR_{pc}.

The average error TAT is deducted from the total process time, resulting in the total value adding time of the process. This will be divided by the total process time to result in the PCE. (15)

$$PCE = \frac{Total\ process\ time -\ Average\ error\ TAT}{Total\ process\ time}\ x\ 100\% \tag{15}$$

Processes with low PCE are better RPA improvement candidates. Because the PCE is based on criteria RPA implementation can have an impact upon, these processes will benefit most from RPA implementation and will increase the efficiency. There is no research that claim a relation between a certain efficiency number and the RPA suitability. We will therefore advise future work on this topic. Our scale is based on the efficiency range (0 – 100) divided by the scoring scale (1 – 5 points), resulting in:

1. $PCE =$ 100 – 80 percent
2. $PCE =$ 79 – 60 percent
3. $PCE =$ 59 – 40 percent
4. $PCE =$ 39 – 20 percent
5. $PCE =$ 19 – 0 percent

Reassign employees

Most businesses are striving towards reassigning saved employees after RPA implementation [11], [27]. In order to be able to reassign employees to, for example, more value adding or customer focused tasks, depends on the amount of FTE saved after RPA implementation. Most sources stated that the best way to measure the reassignment of employees was via the amount of saved FTE after RPA implementation [3], [9], [13], [22], [40]. One source mentioned is was also important to know if those saved FTE really can be reassigned to more value adding tasks [3].

The more FTE an RPA implementation can save, the better the process will be suited for RPA implementation. Processes that save lower amounts of FTE will be less suited for RPA. The criteria will, however, not be based on just FTE reduction alone, but will incorporate the possibility of reassignment as suggested by [3]. As with the ROI benefit calculation, the amount of saved FTE will still be the basis of the measurement and the same number can be applied here. However, because we measure the reassignment of employees, it will be important that those saved FTE's can actually be reassigned in the company [3]. Companies often strive towards the reassignment of employees to more value adding or business objective focused tasks, also increasing the customer satisfaction [3], [9], [11], [22], [26], [46].

To score the reassignment of employees. The estimated FTE saving, performed in the return-on-investment measurement, will be re-used. Because reassigning employees is the goal, we measure the percentage of FTE that can be reassigned within the company. How many of the FTE can actually be reassigned within the company needs to be determined by the assessor. Formula (16) for the reassignment of employees (RE) is calculated by dividing the amount of expected reassigned FTE by the total expected FTE saving from RPA implementation.

$$REp = \frac{Amount\ of\ reassinged\ FTE}{Amount\ of\ saved\ FTE}\ x\ 100\% \qquad (16)$$

Processes with a high percentage of reassignment from the saved FTE score better. RPA implementation will then result in the reassignment of employees to other jobs within the company. Lower levels will show the assessor that the saved FTE might not be used in other places of the company, making it less attractive for RPA implementation.

1. $REp = 0 – 20$ percent
2. $REp = 20 – 40$ percent
3. $REp = 40 – 60$ percent
4. $REp = 60 – 80$ percent
5. $REp = 80 – 100$ percent

Customer satisfaction

"In general, customer satisfaction depends on a lot of different criteria that can be measured like; friendly employees, courteous employees, knowledgeable employees, helpful employees, accuracy of billing, billing timeliness, competitive pricing, service quality, good value, billing clarity, and quick service" [78].

Because RPA is most of the time unlikely to directly impact these criteria due to the nature of the technique, we need to focus on customer satisfaction measurement options RPA implementation can have an impact upon. According to the research sources of customer satisfaction in relation to RPA, the satisfaction can be increased by lowering the amount of errors, reducing the TAT, and by freeing up time to reassign employees to more customer related functions [9], [13]. Other sources don't mention specific measurement options, but do mention that processes with low customer satisfaction can benefit from RPA implementation [17], [20], [22], [40].

Because these criteria are already being measured in the model by there respected criteria, we are not incorporation them into the customer satisfaction as well. Research shows that the customer satisfaction of a process depends on a lot of different factors that can change based on the process, company, and industry [78], [79]. A specific measurement option is therefore deemed out of scope for this assessment model.

RPA assessors can use the turn around time, error rate, and the reassignment of employee criteria to judge potential RPA implementation benefits for customer satisfaction. Because we found that processes with low customer satisfaction are good RPA candidates, the assessor can assess the customer satisfaction criteria with the same range that is used in the other criteria scoring, one to five. Processes with low customer satisfaction score better for RPA suitability than processes with high customer satisfaction. Meaning that the assessor will fill in a five if a process has very low customer satisfaction. It will be up to the assessor to judge the customer satisfaction via already known insight or specific customer satisfaction methods. This way, the model will incorporate customer satisfaction and can still be used in any situation, which is one of our main goals.

Scoring scale will be:

1. Very high customer satisfaction
2. High customer satisfaction
3. Neutral customer satisfaction
4. Low customer satisfaction
5. Very low customer satisfaction

Transparency

With the help of the documentation, log-files, and detection of integrity errors that RPA provides, transparency of a process can be increased [22], [44], [45]. Processes that require more transparency are therefore deemed to be good RPA candidates. The assessment model will incorporate the need for more process transparency. An assessor can score the criteria on its importance for the business goals.

The scoring of transparency will be based on an importance scale. Because processes with high transparency importance are good RPA candidates, this will be rated with a five. Showing that the process or business goal will benefit from the added transparency. Processes with little to no need for added transparency will be scored lower. Thus, wont benefit from the added transparency and will not help meeting certain business goals.

1. Unimportant
2. Slightly important
3. Moderately important
4. Important
5. Very important

Reporting

Reporting has been mentioned in two sources. Both sources build on the fact that RPA implementation will generate additional RPA log-files. These files contain all the steps the bot has taken and thus provide a business with more process information. This information can be used to create new insights when used in reports. In the other scenario, reporting is used as a result of RPA. In this case, the bots are used to build reports from data that was otherwise not usable as input [22], [40].

In both cases, the desire to build reporting about a certain process is key. We therefore decide to measure this criteria by the need of reporting for that specific process. In pair with the other scoring scales, the assessor will need to score this criteria in a range of one to five. This range will clarify the importance of RPA log-files in order to create new reports. Here, five means that the log-file data is very important for the business goals and thus make the process more suited for RPA.

1. Unimportant
2. Slightly important
3. Moderately important
4. Important
5. Very important

4.5. Assessment model workflow

There is a strong consensus that RPA projects should be run via Agile methods [21], [27], [45], [53]. This will help the development stages of the bot to adapt to new insights and help speed up the throughput time of the implementation process. Agile methodologies are known to work with iterations, where the work is split into smaller chunks that are individually worked on and released. Besides these iterations the main focus is on agility and adaptability. Agile processes are not set in stone, but can incorporate and handle new information to improve the current design [80]–[82].

Because an Agile approach for RPA has a strong consensus and is seen as a best practice, our model will also extend on this. We believe that by creating an iterative model, the model will best suite the agile way of RPA implementation. This also suits the RPA implementation roadmap, which is based on Agile principles e.g., the lifecycle is no linear process but rather an iterative process [9].

Combining the two assessment types of criteria with the agile mindset leads us to an initial two iteration model. Here, the assessor will use the model to assess a process in two iterations, separated by the essential and business criteria. The first iteration will use the candidate processes selected by the stakeholders as input. After the first assessment iteration, the remaining processes serve as input for the second iteration, where they will be assessed on the business criteria.

Whilst the process flow of figure 10 might appear to be linear, the assessor can interact with the process at every step, enabling the users to incorporate new information and add new candidate processes if they arise. If a new candidate process becomes in scope, the assessor can start the first iteration with this new process. Depending on the outcome, the second iteration can also be started. The model does not obligate the assessor to finish the complete process before adding new candidate processes. These can always be added during an assessment phase. This is important, because the new candidate process might impact the final selection of the stakeholders in determining what processes will actually be implemented.

If new information becomes available during the assessment, the assessor can always update the model. If new data about the frequency for example becomes available, the assessor can simply adjust the current assessment data and so create a new process score to base the assessment upon. The model does not obligate the assessor to limit the assessment to just one assessment iteration of data gathering session. It is key to have the right information in order to get the best assessment of a process, since all assessment criteria are data oriented.

Not limiting the model to one obligated flow will ensure the support of an agile process method and also not limit the assessor when new information or processes arise.

This chapter involves an “assessor” that can be interpreted as one person. Who the assessor is will be decided by the company but can consist of multiple persons. Most case studies use a combination of business stakeholders to assess and select processes [11], [17], [24], [41]. As also discussed in chapter 1.2 – Research scope, the assessor is best to be a combination of management and process owner.

Figure 10 shows the assessment model workflow in BPMN2.0. This chapter will elaborate the iterations and way of interacting with the model. A complete overview of the model – including the expanded subprocesses – can be found in appendix 9.7 – RPA suitability process assessment model.

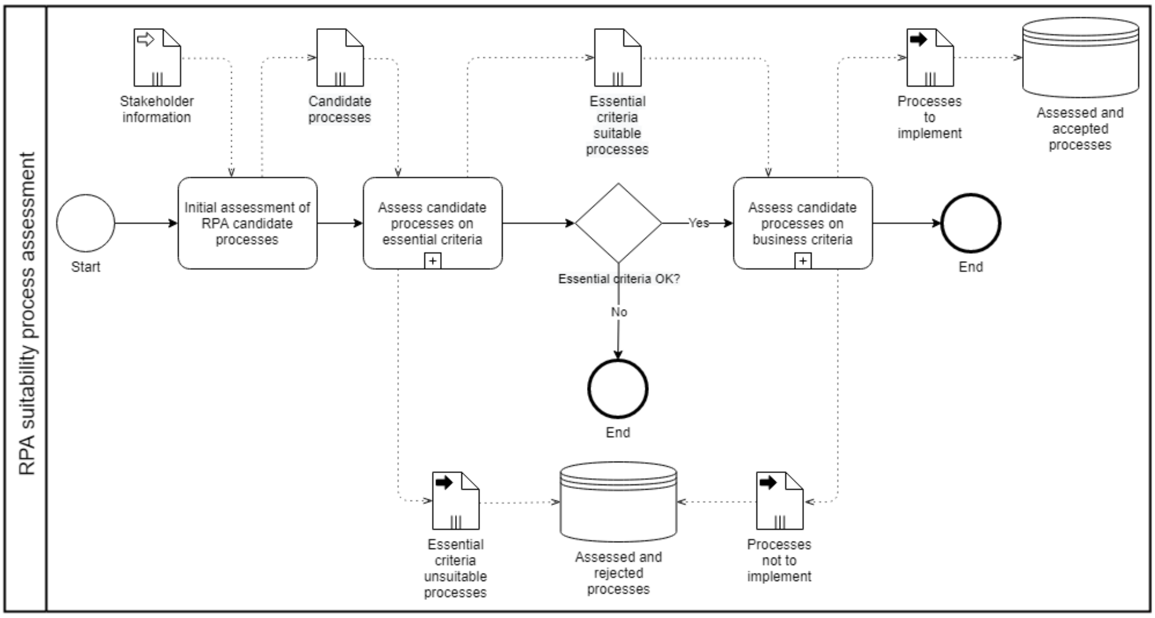


Figure 10 - Assessment model workflow

Initial assessment of RPA candidate processes

This first step of the assessment model workflow is not part of the actual assessment of a process. This step represents the task that needs to be performed in order to generate the input of the assessment model – a list of RPA candidate processes. As proposed by Sigurðardóttir et. al. [9] businesses should first select processes that need to be assessed on RPA suitability. These are the processes that are selected based on stakeholder needs and possible contribution towards the stakeholder goals when automated using RPA [9].

In this step, the assessor uses stakeholder information as input. The assessor will create a first list of processes that will be assessed using the model. These candidate processes are based on input from stakeholders and are not filtered in any way. The list in this task might consist of processes that are not suitable for RPA, but this is not the goal of the step. The goal is to create a list of candidate processes the business likes to automate and improve using RPA. This list will serve as output of this task and also serve as the input for the assessment model's first iteration. As discussed earlier, this step of the RPA lifecycle is deemed out of scope. However, it is incorporated in the assessment model workflow to create a complete picture of the input phase for the assessment model.

First iteration – Assess candidate processes on essential criteria

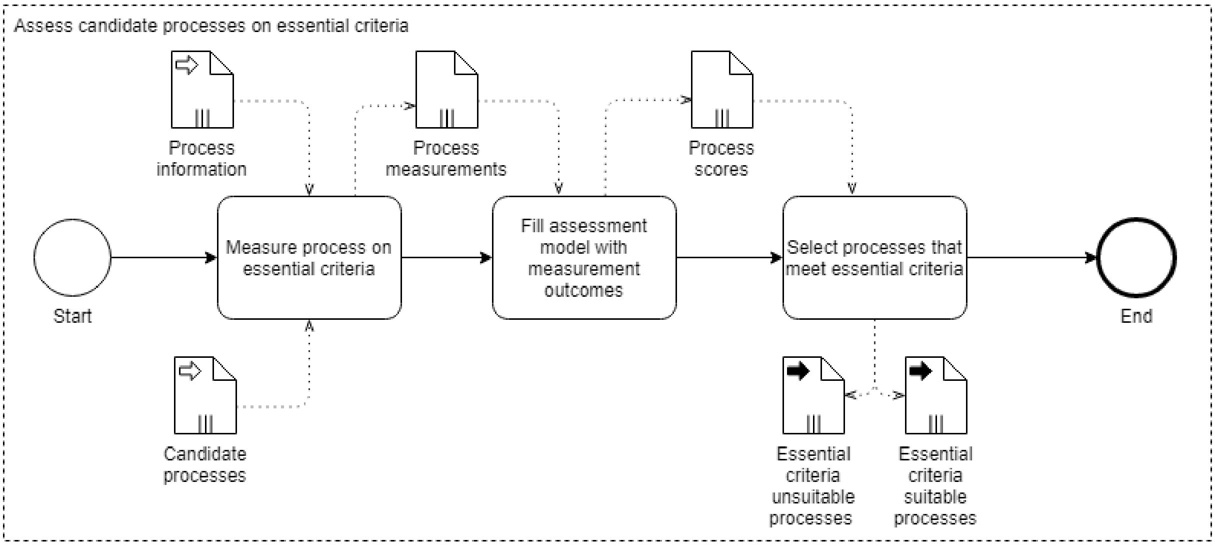


Figure 11 - Assess candidate processes on essential criteria

Figure 11 shows the expended subprocess flow of the collapsed sub-process "assess candidate processes on essential criteria". This subprocess represents the steps that are performed in the first iteration of the process assessment. The input of the first iteration consists of the RPA candidate processes – created in the first process step – and process information gathered from stakeholders to fill the assessment model criteria of the first iteration.

The goal of the first iteration is to assess all RPA candidate processes on the essential criteria. Assessing if the candidate process is suited for RPA implementation. It is therefore mandatory that all questions of the first iteration are answered with "Yes", otherwise the process will be deemed unsuited for RPA as described in chapter 4.4 – Measurement per iteration.

The assessor will start with measuring each process on the essential criteria. During this step the assessor can use different inputs to complete the measurement, like; documentation, stakeholder interviews or observation techniques. The assessor requires enough process information to measure the process on the essential criteria. The measurements will be performed based on the five key questions of the first iteration. Additionally, the assessor can use process mining insights during this step to complete the first iteration.

After measuring the essential criteria, the assessor can start filling the model. In the case of the first iteration, this is done by answering the five essential criteria questions using the measurement information that is required to do so. This task is performed in the model itself and will show the assessor what processes are deemed suitable for RPA according to the essential criteria. This will finally result in two types of process scores: suitable and unsuitable.

The suitable processes will continue the assessment and move on to the second assessment iteration. Processes that are deemed unsuitable will stop here. Processes that are unsuitable according to the first iteration cannot continue to the second iteration in their current form. The first iteration results can be stored by the business, serving multiple possible use cases: knowledge about all assessed processes and why they failed, possible input for process optimalization, general documentation and many more. Processes that pass the first iteration can continue to the second process assessment iteration and get assessed on business criteria.

Second iteration – Assess candidate processes on business criteria

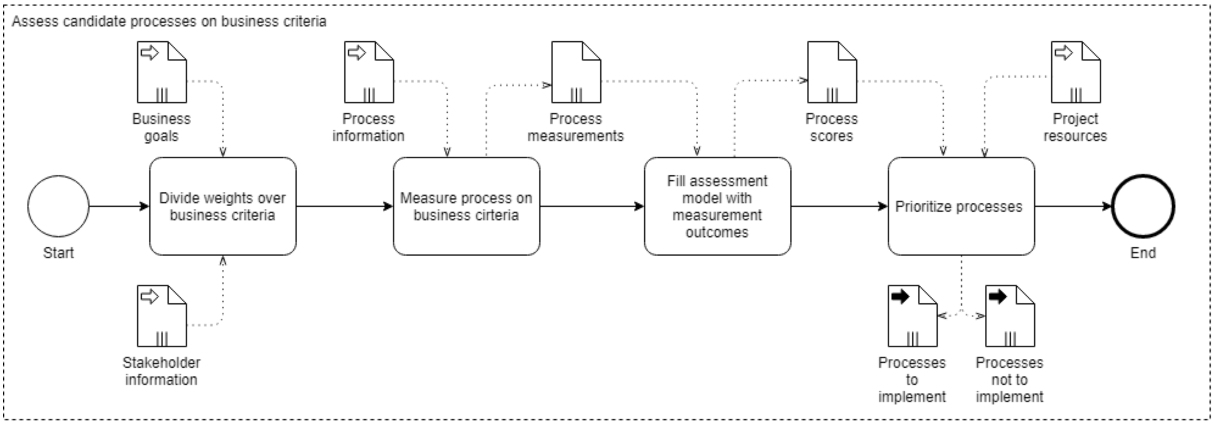


Figure 12 - Assess candidate processes on business criteria

Figure 12 shows the expended sub-process flow of the collapsed sub-process “Assess candidate processes on business criteria” from Figure 10. This sub-process represents the steps that are performed in the second iteration of the process assessment. The input of the second iteration consists of the processes that are deemed suitable for RPA based on the first iteration.

The goal of the second iteration is not to determine if processes are suitable for the RPA technology, because this is already determined in the first iteration. All processes that are suitable to start the second iteration are technically suitable for RPA implementation. The goal of this second iteration is therefore to assess the processes on their ability to contribute towards the business goals via the implementation of RPA.

The second iteration starts with the distribution of the criteria weights. In this step, the assessor distributes the weights over all criteria according to the business goals and objectives. Process criteria that contribute towards the business goals will have higher weights compared to criteria that don’t. If a company was to implement RPA in order to increase the employee satisfaction, this criteria would get a higher weight than the transparency criteria for example. How the weights are divided is up to the stakeholders, the only obligation in the distribution of weights is that the total weight needs to be 100% in order to work as designed.

After the weights are distributed, the assessor needs to fill the model criteria measurements. In order to do so, he will need to measure the criteria on their respected measurements as described in chapter 4.4. In this stage of the assessment, the assessor will measure all business criteria in the process using process knowledge acquired via interviews, process mining and documentation. These process measurements are then used to fill the assessment model criteria, where the measurement information needs to be translated to the 1-5 scoring scales.

When the weights are distributed according to the business goals, and the measurements are translated to the scoring scales, the assessment model will calculate the scores for each process ranging from 1 to 5. Here, processes that score close to an one are suitable for RPA implementation but are less likely to contribute to the business goals after implementation. The closer the score is to a five, the higher the likelihood of business goals contribution by RPA implementation is.

In the final step of the assessment, the assessor prioritizes all assessed processes. He can do this by simply looking at the process with the highest score – which suits the business goals most – or decide to choose another priority based on factors not implemented in the model e.g., limited project resources, stakeholder interests or other external factors. Based on this prioritization, a process will be either implemented or won’t be implemented. The processes that will be implemented will continue in the implementation process for RPA as proposed by Sigurðardóttir et. al. [9]. The processes that are not selected for implementation will be stored for later use or might never be implemented but can suit other purposes like documentation or form a base to perform assessment on other types of automatization.

Process optimalization

Rejected processes during the process assessment are stored for later use or documentation purposes. These are the processes that either failed the first iteration because they are not suitable for RPA implementation or are not being implemented based on the final process selection.

Because all candidate processes require improvement according to the stakeholders, just rejecting a process for RPA will likely not satisfy stakeholder needs. Businesses can decide to adjust these rejected processes based on the assessment model outcome. The assessment model will point out specific section(s) a process has failed to meet the criteria and therefore failed, giving the business valuable information for potential process optimalization.

For some of processes, RPA will never be an option. Others, however, might first need to be optimized or slightly adjusted in order to make them suitable for RPA. Adjusting the processes before or during implementation is a best practice according to many studies [15], [22], [27], [41], [42]. Unsuitable processes might still be high on the business priority list and can therefore be improved to meet RPA requirements. The outcome of the first – failed – assessment can be used by businesses to improve the process.

If a process for example fails on the amount of standardization, businesses could try and improve the process to better suite RPA by reducing the number of exceptions in the process. This way, the information from the first failed assessment can serve as input to improve the process and make it more suitable for RPA implementation.

After process optimalization, the processes can start at the beginning of the RPA assessment model workflow and be re-assessed. There is now a greater change for the process to pass the assessment and be successfully implemented for RPA. This optimalization thus creates a better process for RPA implementation and will help the business to automate high priority processes that otherwise would have failed RPA implementation.

This optimalization and re-assessment of a process can create a loop where processes that have high business value can be optimized and assessed. This loop can be performed many times, until the process passes the assessment. Supporting process optimalization loops with the model also suits the agile methodology, where change during a process can always be used and should not be ignored.

Processing newly acquired information
New information about a process or the introduction of new processes in general can present themselves over the course of the assessment. Especially when an Agile project method is being used. To show the flexibility in the model, we will describe how newly acquired information can be used throughout the assessment model workflow.

New information can come in two forms: new measurement information or a new process that needs to be assed. Both of these can be used in combination with existing assessment progress because the model does not only support linear use.

During one of the two assessment iterations, new measurement information about a process can be acquired. This can happen for example because the assessor wants to validate stakeholder information using process mining or documentation is found and analyzed after assessment. This new information can impact the outcome of the assessment and should therefore not be neglected by the assessor.

If new information arises, the assessor can adjust the measurement information that was currently present in the model. If the adjustment is significant enough to result in a different score, the assessment model will show this. Essentially, the assessor creates a new process assessment iteration with the newly acquired information.

It is also possible that new processes arise during or after the assessment phase. This can happen based on management decisions or a shift in priority. The assessor can start the assessment model workflow with this new process and add the result to the existing process assessment results. He can now compare the results of the new process with the already assessed processes and make decisions based upon this.

4.6. Artifact requirements conclusion

During the design chapter of this thesis, we created a new artifact with the goal of fulfilling the created artifact requirements. These requirements had connected contribution arguments that elaborated the purpose of the requirements and showed the importance of completing these. During the design chapter, we created an artifact that meets the artifact requirements and fulfills the contribution arguments. We did this by analyzing the literature review outcomes and designing an artifact based on this acquired knowledge.

However, not everything could be created based on the findings in literature. For some of the artifact designs, no literature could provide us with the required knowledge. To overcome this and still create a suitable design, we created our own solution derived from literature insights and common sense. Via the combination of literature and a design science mindset, we where able to satisfy all artifact requirements. The outcome of the design phase – the assessment model – can be found in appendix 9.18 and 9.19, together with a brief explanation of all aspects and the relation to their respective chapters in this thesis.

R1 – The artifact must consist of RPA criteria to assess process suitability
The goal of this requirement was to create a set of criteria that helps the assessor with the selection of processes that are suitable for RPA implementation. This was based around problem statement, which showed that it is important to know which processes are and are not suitable for RPA and so reduce the chance of a faulty assessment.

In order to satisfy this requirements, we created two iterations of process assessment. The first iteration assess a process on the RPA process suitability. Deeming a process suitable of unsuitable for RPA based on the essential criteria. This first iteration is completed by answering five questions about the process regarding the essential criteria. If all are answered positively, the process is deemed suitable. If one or more essential criteria fail to be met by the process, the process is deemed unsuitable.

Looking at our contribution arguments, we believe that by the use of essential criteria and a specific iteration, we support the need of the assessor to assess a process on RPA suitability and thus satisfy this requirement.

R2 – The artifact gives business the possibility to assess the process on business goals using RPA
The goal of this requirement is to fill the gap that is currently present in literature. Many researchers suggested that RPA implementation is not about the technology itself, but rather about the contribution towards business goals. A part of RPA process assessment there is currently not enough information about.

In order to fill this literature gap and provide a way to assess a process on RPA business goal contribution, we designed a way to assess a process on RPA improvement potential by the introduction of business criteria. These business criteria are derived from known benefits RPA implementation can have on a process. Via a second iteration, using only suitable processes, businesses are able to assess their process on these business criteria and see to what extend RPA implementation will contribute towards their goals. Like the essential criteria, we designed measurement option for all business criteria which are embedded in the assessment model.

According to our contribution argument, this requirement will be fulfilled if business goals can be measured using the assessment model. As shown by our design, we incorporated this need into our model by designing measurements for business criteria which represent the added value RPA implementation can have on a process. Businesses can use these business criteria to assess the improvement potential on certain process aspects and translate these to their business goals. We believe that our design therefore satisfies this requirement.

R3 – The artifact shows what processes are suitable for RPA
In order for this requirement to be satisfied, we need to design a way for the assessor to understand which processes are suitable for RPA and to what extend they contribute towards the business goals.

To incorporate this into our model, we designed a weighted scoring mechanism to score all business criteria. We did not design this for the essential criteria since they are all essential and need to be present in order for RPA to be deemed suitable. The business criteria are independent of RPA suitability, but rather focused on the added value RPA can bring to a process and business. All of the acknowledged business criteria are valuable and applicable for all RPA projects, however, not all businesses have the same goals when implementing RPA.

To keep the model relevant in all situations, we did not want to exclude business criteria. We therefore incorporated weighted scoring for businesses to use during the assessment and represent their business goals with RPA implementation. Via the use of weights, all criteria scores can be influenced according to their business goal contribution. Business criteria that contribute towards the business goals must be increased and criteria that do not, must be lowered. It is up to the stakeholders to decide this distribution.

By increasing the weights of the important criteria, the assessment model scores will be impacted. Now, criteria that have higher weights contribute more towards the total process score. This means that the processes with high scores contribute most towards the business goals in comparison to processes with lower scores.

Via the implementation of weighed scoring we designed a way to assess a process on the business goal contribution of RPA, whilst still keeping the model relevant and applicable in all situations. This supports the contribution argument of this requirements and will help the assessor the conclude process suitability.

R4 – The artifact supports the use of process mining
This requirement is created based on the findings in literature. Multiple studies showed that process mining can have added value when incorporated in to the process assessment. To extend on this, we conducted a literature review on this topic and concluded that process mining can be used during the assessment. The goal during the design was to incorporate process mining in a way that it will improve the assessment but does not become mandatory. Keeping the model accessible for businesses without process mining to their disposal.

We did this by explaining how process mining can be incorporated during the process assessment in chapter 4.3. This is an addition to the criteria measurements, which are created without the need of process mining.

By designing the criteria measurements without the need of process mining, we kept the model accessible for all companies. Business that have process mining at their disposal can use this as described in chapter 4.3. This way we satisfy requirement four and support the use of process mining in a way that businesses that have access to process mining can utilize its added value during the assessment and for businesses without process mining to still be able to assess their processes on RPA suitability and business goal contribution.

5. Validation

Now that the artifact has been designed it is time to validate its use in the problem context. Validating the created artifact in its problem context justifies its contribution to the stakeholders' goals and created requirements in a real-life setting. Based on the created requirements, research questions, outcomes of the literature review, and design phase, the model satisfies all pre-defined requirements. However, it is yet to be validated if these requirements are also fulfilled in the problem context.

The design problem is based on a combination of a literature gap and difficulties in the problem context. To validate the use of the created artifact, it will be important to understand the use of the model in the problem context it is designed for and validate its contribution towards the requirements and stakeholder goals in a real-life situation. In order to do this, we will be using a case study at Rexel Nederland, specifically the Service Desk department.

During the cases study validation, we will stay focused on the validation with the help of pre-defined validation questions. These questions will be the main focus of the validation and correspond with the requirements of the assessment model. After the creation of the validation questions, we will elaborate how the case study will be conducted and finally, show the results.

5.1. Validation research goals

Treatment validation is the last step in the design cycle. Here, Wieringa et.al. [31] defined a couple of important kinds of knowledge questions specifically for validation research. In this part of the design cycle, it is important that the artifact is validated in its context. With the help of predefined knowledge questions, the case stays focused and has clear goals.

Wieringa et. al. [31] provides four different kind of knowledge questions to prepare before conducting treatment validation: Effect questions, Trade-off questions, Sensitivity questions, and Requirement satisfaction questions. By creating these questions, we are able to prevent drowning in the potentially infinite mass of data and focus on the data that is available and necessary to answer these questions and validate the model.

By answering the validation questions, we validate the model use in relation to the current literature gap and created requirements.

Effect questions

Effect questions are focused on the results that come from the interaction between the artifact and its knowledge context. In our case, this will be effect of the interaction between candidate processes (problem context) and the assessment model (artifact). Here we will validate the selected solutions to our requirements from chapter 2.3 by tracking the effects they have on the problem context.

Looking at our requirements, the artifact is designed to assess processes on RPA suitability and business goal contribution. The effect coming from the interaction between the processes and the assessment model can be described using the following effect questions (EQ):

EQ1 – What is the effect of the first iteration on the candidate processes?
EQ2 – What is the effect of the second iteration on the candidate processes?
EQ3 – What is the effect of the scores as a result of the assessment?
EQ4 – What is the effect of the weights on the process assessment?

Trade-off questions
Trade-off questions (TQ) are created to see how different versions of an artifact interact with the problem context. In this thesis we did not specify different artifact versions because we limited the scope to just one iteration. We do however have an optional process mining implementation which will be used for the trade-off questions. This way we can specifically validate the impact process mining can have on the assessment and see if the predicated benefits are also present when interacting with the problem context.

During the literature review, we found that process mining can help the assessment by reducing the time it takes to assess a process, improve the assessment by using data-based facts. We incorporated this into our model as a supportive function to reduce the time it takes to complete the assessment and use process mining to measure each criteria more precise. We created the following trade-off questions to validate these found benefits and compare them to a completely manual assessment:

TQ1 – Does process mining decrease the amount of time it takes to complete the first and second iteration?
TQ2 – Does process mining impact the outcome of the assessment compared to the assessment without process mining?

Sensitivity questions
Sensitivity questions (SQ) are focused on the behavior of the artifact in different contexts. These are mainly focused to find out if the artifact works in multiple situations. In our case validation, the sensitivity questions will be answered by using different processes that will be assessed. One of the goals was to create a model that was not limited to one situation. To get an idea about its usefulness in other departments of Rexel Nederland, we added SQ2. Due to the time constraints of this thesis, we are unable to test the assessment model in other companies. We created the following sensitivity question to validate the model with multiple processes and in different scenario's:

SQ1 – Are there processes that could not be assessed using the assessment model?
SQ2 – Would other departments at Rexel use this model for RPA process assessment?

Requirement satisfaction questions
Requirement satisfaction questions are based on the requirements that have been created in the beginning of the thesis. Here, the treatment validation is focused on finding if the artifact actually satisfies the requirements in the case study problem context. The requirement questions are based on the already created requirements. This resulted in the following requirement satisfaction questions (RSQ):

RSQ1 – Does the artifact assess a process on RPA technology criteria?
RSQ2 – Does the artifact provide the possibility to assess a process on business goals?
RSQ3 – Does the artifact show what processes are suitable for RPA?
RSQ4 – Does the artifact supports process mining in a voluntary way?

5.2. Case study

Here we elaborate on the case study that is being performed at Rexel Nederland. This chapter will elaborate on the case study context, case selection for the study and how the validation questions will be tracked and measured in order to be able to answer them at the end of the case study.

5.2.1. Context

The case study will be conducted at Rexel Nederland, specifically at the Service Desk department. Here, a Service Desk team solves requests from internal and external customers related to price and logistics errors, questions, and general requests. The goal of the Service Desk team is to complete these request within a certain time span depending on the request and making sure that the customers are offered fitting solutions to their requests. The Service Desk department is currently unable to do so due to the high workload and underemployment and wants to change this with the help of automation.

Currently, the Service Desk team is struggling to keep up with the amount of work and is unable to complete all incoming tasks in the expected time span. This results in a lot of pressure for the employees, and low customer- and employee satisfaction. The goal of the Service Desk management is to complete all incoming tasks in the expected time span by freeing up FTE that is currently allocated to perform repetitive tasks that need to be performed, but do not add a lot of value towards the core goal of the Service Desk team – solving customer problems.

The management of the Service Desk worked together with the Service Desk team to create a list of processes that they wanted to improve in order to free up FTE which can then be re-allocated to customer related tasks. They first investigated the traditional automation potential, but this was deemed unfeasible. Their next step is to assess these processes on RPA suitability, since RPA is known for automating processes that are not feasible for traditional automation but can be using the lightweight RPA solution [5].

Because the Service Desk team works with external- and internal customers, use a lot of different applications, and has multiple processes ranging from warehouse management to customer satisfaction processes, we believe that this department will create a good case study candidate.

One of the main goals of the assessment model is that it must work in different context and should not be limited to one specific situation of company. By conducting the case study at a department that handles various processes in different context, we represent a case study over a wider range of processes. This way, we can test the assessment model in different kinds of processes and not limit the case study to one specific type of process and context. In this way we hope to partially eliminate the limitations of validating at just one organization.

The goal of our case study at Rexel Nederland is to find answers to our Effect questions, Trade-off questions, Sensitivity questions, and Requirement satisfaction questions. Ultimately testing how the artifact behaves in its problem context and to what extend the requirements and goals are fulfilled. For Rexel Nederland, the goal is to assess their processes on RPA suitability and see which processes best help achieve their goal of increasing the employee satisfaction, reducing the time spend on the process by eliminating human error and finally free-up FTE due to the high workload currently present at the Service Desk.

All participants in de case study are informed that they are free to stop their participation at any time and expressed consent to the participation of this validation.

5.2.2. Case selection

The goal of this validation is to test the artifact in its problem context and answer our validation questions. Because of this, we did not construct a case to answer the questions. This would not be representative to its problem context and might lead to cherry picking [31]. The cases for this validation are therefore selected by the problem context, resulting in a validation that is representative to the problem context the artifact will be active in and also corresponds with the RPA lifecycle according to Sigurðardóttir et. al. [9].

Looking at our validation questions, we need to find answers for twelve validation questions. The likelihood of this succeeding in this goal using only one process is very low. Having a set of multiple different processes to study will increase the amount of data and will increase the likelihood that the validation questions can be answered. Besides this, a wider range of processes to study will also show the all-round use case the model aims to achieve.

There are a couple of cases that need to be present in order to study our validation options. Because the model consists of two iterations, we need a process that fails at the first iteration – showing the effectiveness of this assessment iteration, and processes that can be scored and compared in the second iteration. Besides this, we also need a process that can be assessed with the help of process mining in order to assess the impact process mining has on the assessment.

With this case selection, we believe that all validation goals can be met and are representative to the problem context. We did not interfere with the case selection as is proposed by Wieringa et. al. [31] Instead, the Service Desk team created a list of candidate processes. This was done via the proposed steps in Sigurðardóttir et. al. [9] and also represented in our assessment model workflow (figure 10).

This first step created a variety of candidate processes that the service desk likes to improve. During the cases selection, the Service Desk team did not filter any processes and only focused on processes that are currently not contributing towards the goal of the service desk and hinder their daily work. All of these candidate processes are selected for the case study and can be found in appendix 9.8 – candidate processes.

5.2.3. Measurements

In order to answer our validation questions, we need to track and measure the outcome of the validation and use these measurements to answer the validation questions. This section will elaborate on the measurement design checklist as proposed by Wieringa et. al. [31]. This includes the required measurements for each validation question and show the data sources, measurement instruments, and validity of measurements specifications on inference, repeatability, and ethics.

The main goal of the validation is to see if the assessment model helps with the process assessment for RPA and fulfills the main goal of the research: A*ssess a process on its RPA suitability, whilst also taking business goals into account*. Most of the validation questions are therefore focused on tracking the processes through the assessment model and see the outcomes of the interaction between the process and the model. Other validation questions are specified towards different versions of the model and require keeping track of time. We will elaborate each measurement per validation question type.

Effect questions

Data source

The effect questions are focused on the outcome of the model. Our main measurement data source is therefore the assessment model itself. The assessment model will change over time when more data is added to it. In order to answer EQ1, we can analyze the number of processes that did not meet the criteria specified by iteration1 and conclude the results. For EQ2 – EQ4 we will analyze the differences in input, score, and weights after the second iteration.

Measurement instruments

To measure the effective questions, we do not need any additional measurements instruments besides the assessment model outcome. It is crucial however that the assessment model results are saved, and we therefore created a repository for the participants to use.

Trade-Off questions

Data source

The trade-off questions are about the difference process mining makes in comparison to a process that is not assessed with process mining support. To see the difference process mining can make, we will assess one process two times, once without process mining and once with process mining. This way we can see the differences process mining has on the outcome of the assessment for the same process and analyze the differences.

Our main data source here will be the assessment model outcomes of both versions of the process assessment. Besides that, we need to have access to process data in order to use process mining.

Measurement instruments

Looking at our trade-off questions, we need to validate the process mining support by analyzing the differences between the assessment outcomes. We analyze the data provided by the filled assessment model in order to spot the differences and compare the outcome with and without process mining. TQ1 requires us to measure the amount of time it takes to complete the assessment with and without process mining. Since this is not a part of the assessment model, we need additional measurement instruments that help us to track the duration of the assessment. We will measure the time it takes to perform each iteration with and without process mining and track this in a different document.

To track this data, we will start a timer when the first assessment iteration starts and stop the timer when the first iteration is finished. The same method will be used for the second iteration. The timer will include all time required for the completion of the assessment. Without the process mining, this might include analyzing documentation and any necessary meetings to fill the model, but also any time spend tracking the human errors over a one-week period. For the process with process mining, this will include all of the above and also creating a process mining model, analyzing the model and any additional tracking that needs to be done if process mining is not applicable. All measurements will be tracked in a worksheet and analyzed at the end of the validation to answer all trade-off questions.

By tracking these additional parameters during the assessment, we are able to compare the assessment with and without process mining and answer the validation questions.

Sensitivity questions

Data source

The data source of SQ1 is a completed assessment. Here, we can analyze the assessment model at the end of assessment to see if any fields are still open. We also ask the participants to communicate any failed assessment with the corresponding reasoning. These will be documented if needed.

SQ2 requires a different data source in order to be answered. Due to the limited time available for this thesis, we are not able to assess processes from multiple departments of Rexel. We therefore use a feedback questionnaire to evaluate acceptance of the assessment model, the perceived effectiveness of the assessment model and additional recommendations to the model.

This questionnaire will be carried out at management level of Rexel Nederland for the following departments: IT, Finance, Marketing, Sales, Service Desk, and E-business. This population represents the stakeholder level the model will be used at and that is described in 1.2 Research Scope. All participants have the desire to improve their processes using automation and see RPA as a valuable option for this. The participants all hold master's degrees in their respective fields.

Via this questionnaire, we can gather information from different departments and so judge if other departments will use the model. To some extent, this will validate the use and acceptance of the model in other scenario's then the service desk.

Measurement instruments

To measure SQ1, no additional instruments will be required besides the final assessment results.

SQ2 will be measured via a feedback questionnaire. The goal of this feedback questionnaire is to gather feedback on the assessment model acceptation based on the constructs discussed in [83]. We adapted these constructs and created definitions for them that will be used in this questionnaire. Additionally, we asked the participants to leave improvement possibilities for the assessment model. Table 2 shows the definition per construct.

We inform all participants about the model via a live presentation and also supported this by sending a draft version of the thesis containing all relevant information about the model. The participants had the option to prepare questions in advance of the presentation – because the thesis was sent 1 week in advance – and also ask questions after the presentation to ensure that the participants understand the model before answering the questionnaire.

The questionnaire is filled in after the presentation and questioning round. All participants can fill in the questionnaire via an online questionnaire program and those results will be analyzed and concluded in de result section. We included possibilities to elaborate their scores for each questions. The scoring of the questionnaire will be done via the Likert scale, where the participants can score the construct in one of the following: Very unlikely, Unlikely, Neutral, Likely, Very Likely.

The results of the questionnaire will give us an idea about the acceptance of the RPA assessment model in different departments of Rexel and validate the model in multiple departments.

Table 2 - Construct definitions for SQ2 questionnaire

Construct	Definition
Perceived Usefulness	The extent to which the questionnaire participants believe that the model will improve their RPA process assessment
Perceived Ease of Use	The extent to which the questionnaire participants believe that the model will be free of effort
Subjective Norm	The extent to which the questionnaire participants believe that people important to them think they should use the model (e.g., Board of Directors, colleagues)
Voluntariness	The extent to which the questionnaire participants believe the model will be used voluntarily to assess processes
Compatibility	The extent to which the questionnaire participants believe that the model is consistent with existing values, needs and past experiences of potential users of the model

Requirement satisfaction questions

Data source

The requirement satisfaction questions are created to validate the requirements in practice. In order to do so, the case study is conducted. This case study will show us how the assessment model will perform in its problem context. We can therefore use the outcome of the case study as validation data source. By doing so, we can analyze the outcome of the iterations and see if the assessment model fulfills all requirement satisfaction questions.

Additional to the outcome of the model, we like to validate the requirements with the stakeholders that use the model and are the main users of the model during RPA process assessment. By doing so, we not only validate the requirement satisfaction in a quantitative manner, but also a qualitative manner. Assuring that any (dis-)satisfaction of the requirements that might not be spotted in the assessment model outcome analysis can be spotted and considered using an interview with the management of the Service Desk.

Measurement instruments

In order to measure the requirement satisfaction questions we will need to use a combination of the case study results and interview outcomes. For this, we created interview questions – 9.9 Interview Service Desk manager for RSQ1 – RSQ4. During the interview, we will ask the Requirement Satisfaction questions and log the response. The interview will be held with the Service Desk manager, who is responsible of creating decisions based on the outcome of the assessment model. He can therefore best assess if all requirement satisfaction questions are being met and provide additional feedback on this process.

Validity of measurement

Measurement Inference

During this case study, a great portion of the later analyzed data will be created and documented in the assessment model. These results will be stored and used to later analyze and conclude the answers to the validation questions. A great part of the inference will not be eligible for discussion since it is based on data. For some validation questions we do need to analyze the data from the case study in order to create conclusions. In order to increase the validity of this, we will also double check the outcomes of this study with the case study stakeholders and participants.

Measurement Repeatability

To increase the repeatability of the case study, we described all data sources and measurement tools. Combined with the assessment model and criteria explanations in this thesis, we believe that the case study will be repeatable for other researchers. However, the exact same processes in the same environment are most likely not available for other researchers. Decreasing the complete repeatability of the cases study.

Measurement Ethics

The supporting company whishes to keep the process flows, detailed information about the process and the case study participants confidential. We respect this by not mentioning participant personal information and also not to include process flows, datasets and other information. All information shared in this thesis is also in consent with Rexel Nederland. We do not believe that these restriction of information sharing harm the case study nor its results and validation. All relevant results and outcomes of the case study will be shared and available in the thesis. Exact process information and details are not mentioned but also required for this case study and validation of the model but could have provided more information about the processes for understanding purposes.

5.2.4. Case study execution

The goal of the case study execution is to follow the designed assessment model in its problem context. In our case, this will be in the problem context of the Service Desk at Rexel Nederland. For the execution of this case study, no adjustments have been made to the problem context in order to validate the model, we will be using the real problem context for this case study as also suggested by Wieringa et. al. [31].

In order to validate the designed model, we follow the Assessment model workflow – figure 10 from page 61 as it is part of the designed assessment model. This workflow illustrates how the assessment model will be used in the problem context in order to complete the assessment of all candidate processes. During the case study, all steps of the model will be precisely followed according to the described assessment model workflow. All candidate processes will be used during the case study where one of the processes will be assessed twice in order to validate the use of process mining.

Measuring the criteria is an essential part of the assessment model. The measurements are completed by the process owners of each process in combination with an employee from the IT-department [9]. Due to the importance, we explained each criteria and criteria measurement in detail to the participants of the study. By doing so, we minimize any possible misinterpretations of the criteria and measurements. Due to a slight language barrier present with some participants, we also translated the criteria and measurements to their native language – Dutch. After this, all participants confirmed that they understood all criteria and the measurement options connected to them. During the case study, we where always on standby to answer any questions about the criteria, measurements and case study in general.

The first iteration was performed together with all process owners of the candidate processes. Every process owner was able to complete the first iteration, no process owner had any problems with understanding nor completing the assessment. Most completed the first iteration based on process knowledge in combination with existing documentation on the process.

Depending on the outcome of the second iteration, some process owners conducted the second iteration as well. Here, most of the required knowledge on the process was available to them and didn't form any problems. However, the assessment on RPA cost could not be completed without the help of the RPA supplier.

During the assessment, we interviewed the RPA supplier of Rexel for an estimated cost of all of the remaining process in iteration two. This was necessary to estimate the cost of the process and so determine the ROI score, the process owners where unable to do so. The RPA supplier estimated all process around €2,000 to implement and €2,000 annual cost of the bot. Making the total cost per process €4,000.

The distribution of weights is determined by the management of the Service Desk. As described by Sigurðardóttir et. al. [9], management level should determine the goals and make sure that these goals are being tracked during RPA projects. Because the business goals are translated to the model by the weight distribution, management was responsible for this task.

As part of the case study, management from the Service Desk, but also from other departments are being interviewed about the acceptance of the model. Before we started the presentation, some participants acknowledged that they did not prepare the meeting by analyzing the model in advance. This often resulted in multiple questions after and during the presentation. Before conducting the questionnaire, we ensured and confirmed that everything was clear to all participants. There has been a total of six participants that completed the questionnaire.

In order to complete the requirement satisfaction questions, we also interviewed the manager of the Service Desk after the completion of the cases study. All assessment model outcomes are also shared with us in order to analyze. Besides the assessment model itself, we also asked the participants to track the time spend on the completion of the model. All participants returned all asked information, resulting in a 100% respond rate of the case study.

5.3. Results

This chapter will elaborate on the results of the case study. This will be done via the earlier created validation questions and measurement information. During the result section, we will show the validation of all questions and finish with a discussion section about the case study.

5.3.1. Answers to validation questions

Effect questions

In order to answer the effect questions, we analyzed the changes to the assessment model throughout the iterations. All of the fourteen candidate processes have been assessed using the model, resulting in a 100% respond rate. We analyzed the outcomes of each iteration via the results of the assessment model per assessed process. The differences between the processes and the general outcome of each iteration is our main source to answer the effect questions.

EQ1 – What is the effect of the first iteration on the candidate processes?

At the start of the first iteration, all candidate processes are being used. This is because the first iteration is focused on assessing the candidate process on their RPA suitability. To perform the first iteration, all five main questions about the process need to be answered. These answers are based on process knowledge gathered by the process owner. Full results can be found in appendix 9.10 Results iteration one – essential criteria

Tabel 3 shows the results after the first iteration. This shows that nine out of fourteen processes did not pass the first iteration assessment and five processes did. The first iteration reduced the amount of candidate processes by 64%. Most of the failed processes where not deemed suitable because these processes did only meet four out of five criteria. Four out of fourteen processes met less then four criteria.

Iteration 1	
Score	Frequency
1 out of 5	1
2 out of 5	1
3 out of 5	2
4 out of 5	5
5 out of 5	5

Table 3 - Frequency of failed criteria

Iteration 1	
Criteria	Fail frequency
Standardization	4
Rule based	5
Data availability	5
Data structure	2
Maturity	1

Table 4 - Frequency of processes not meeting an essential criteria

Tabel 4 shows the number of times a process failed per essential criteria. Most of the time, processes where unable to be defined using business rules and thus required creative thinking of employees, or the process was not completely digitally available. For one of the processes this was for example because the input of the process was based on stock levels that where being tracked via Sticky Notes.

The effect of the first iteration was that most of the candidate processes failed the first iteration assessment. This shows that the first iteration is able to reduce the amount of candidate processes based on the five main questions for RPA suitability. The remaining five processes will continue to the second iteration to be assessed on the business criteria.

The first iteration lets the assessor know in, on average, twenty minutes if a process if suitable for RPA or not. By performing a split assessment and filtering out these unsuitable processes using a relatively fast iteration, assessing a process on both essential and business criteria won't be necessary. Saving the assessor a lot of time assessing a process on business criteria that might not pass the essential criteria assessment if no split assessment method was being used.

EQ2 – What is the effect of the second iteration on the candidate processes?

The second iteration consists of candidate processes that passed the first iteration. The second iteration is focused on assessing all remaining candidate process on their contribution towards business goals after RPA implementation. This is done via a much more extensive assessment using multiple criteria and for some criteria measuring these over a period of one business week. Full results of iteration two can be found in appendix 9.11 Results iteration two – business criteria.

The effect of the second iteration on the candidate processes is mainly focused on measuring the process on the business criteria. All processes that start the second iteration will be assessed on fifteen criteria via their respective measurements. Unlike with the first iteration, the assessment of the second iteration takes up a lot more time because of these extensive measurements.

The average time spend on the completion of the first iteration is around twenty minutes per process. The average time spend on the completion of the second iteration is around four times that of the first – 84 minutes per process. This difference is mainly due to the fact that the assessment of the second iteration is much more extensive and involves many more criteria that need to be measured. This results in more data tracking or analyzing documentation with the help of stakeholders.

The time spend per process depends on the amount of available documentation and information in general about the process. Process four had relatively new and complete documentation that resulted in a lower time that had to be spend on filling the assessment model compared to process seven which had almost no documentation.

Whilst the average time spend on the completion of iteration two is 84 minutes, the throughput time is much higher. For the criteria: frequency, human error, and turn around time, five days worth of data needs to be tracked. Actually tracking and documenting this information does not take a lot of time, since the process experts track the numbers throughout the day and note these measurement at the end of each day. However, it does take at least five days to complete. In order to complete the cost measurement for the ROI criteria, the RPA supplier provided Rexel with an estimated cost.

When all measurements are complete, the effect of the second iteration on the candidate processes is that this iteration scores all processes based on their positive contribution towards the business goals. The case study outcome of the second iteration gave the Service Desk manager enough information to base his decision upon according to the interview that was conducted – Appendix 9.9 Interview Service Desk manager for RSQ1 – RSQ4. Dividing the weights based on the business goals took the Service Desk manager about one hour to complete.

To conclude, the effect of the second iteration on the candidate processes consists of two parts: gaining knowledge about the process and tracking measurements, and scoring the process based on the business goal contribution. Here, the average time spend on the second iteration is around 84 minutes per process and has a throughput time of at least five days. Dividing the weights for the second iteration took around 60 minutes and is applicable for all processes.

EQ3 – What is the effect of the scores as a result of the assessment?

The goal of adding scores to the process assessment is to easily show what processes contribute most towards the business goals. This means that processes closer to a five are better automation options then processes closer to a one. The total process scores are determined by the sum of all individual criteria scores multiplied by their respective weights.

During the case study, P3, P4, P6, P7, and P11 received scores. This is because process scoring is only applicable for processes in the second iteration of the process assessment. There are two types of scores in the model: a total process score and a criteria score. The detailed outcome of all process assessments can be found in appendix 9.12 – 9.16. This chapter will highlight certain aspects of these outcomes and so conclude the effect of the scores on the assessment.

The total process scores are ranging from 2,23 to 2,70. Based on the total range of five points, this means all processes score within 9,4 percent of each other. Whilst this might not seem like a big range, the Service Desk manager stated that the difference was enough for him to base a decision upon. Some processes came up above the middle of the scoring range (2.5) and some came out below. The service desk manager used this as an indicator to judge the process scores and said that he would primarily focus on processes four, six, and seven, since they are above the middle of the scoring range. Since all processes are suitable for RPA implementation and in need of improvement, he felt comfortable to continue with all if the budget allowed him to. However, if he had to choose between processes, he would go for the highest scoring process. The scores helped him with this.

The case study resulted in two processes with almost the same process score. Since the scores are so close, it was more difficult to make the right decision on what process to continue with. The model currently does not have a specific way to make a distinction between two processes with almost of completely the same score. The Service Desk manager told us that if he was to decide between two processes with almost the same scores, he would look for the criteria scores with the most weight or pick the process with the highest business importance.

Extending on this, we created table 5. This shows the contribution of the scores with high weights – Human Error, Efficiency, Employee Satisfaction, Time Saving, and Reassign Employee – to the total process score.

Table 5 - High weight score contribution

Process	Total scores	Increased weight scores
P3	2,35	1,38
P4	2,55	1,36
P6	2,68	1,46
P7	2,70	1,78
P11	2,23	1,38

This shows that while process six and seven both result in the highest scores, process seven has the highest score on the criteria that the Service Desk finds important towards their business goals. From this point of view, the higher score on the important criteria would favor process seven over process six. Whilst this is currently no part of the model, it will be interesting to see future research extend on this idea.

The total process score does show what processes contribute most towards the business goals by resulting in different scores per process. During the interview, the Service Desk manager stated that this difference gave him enough information to select what processes to continue with. He was also able to select the best processes to start with within the project budget. He stated that not all five processes can be automated with the project budget and that he can most likely only pick two. Based on the outcome of the assessment model he can easily spot and select the two best processes to automate and contribute towards their business goals. The three remaining processes will not be automated and stored for possible later use. The effect of the scores on the assessment is that the stakeholders can select the processes that contribute most towards their business goals by judging the order of the process score outcome.

EQ4 – What is the effect of the weights on the process assessment?
The designed effect of the weights on the process assessment was based around tailoring the model to a specific business situation. This way, the assessment model could be generic but still be focused on specific business goals and situations. Making it general enough so that all business can use the model, but still useful for business that have different goals with their RPA implementation.

At the start of the second iteration all weights where evenly spread over the criteria resulting in a criteria weight of around 6,67%. Since the Service Desk had clear goals for their RPA implementation, they translated these goals to the assessment model weights. The goals of the Service Desk for their RPA implementation was that they desired the RPA to increase the employee satisfaction, reduce the time spend on the process by eliminating human error and finally free-up FTE due to the high workload currently present at the Service Desk.

With these goals in mind, the Service Desk manager increased the weights of criteria: Human Error, Efficiency, Employee Satisfaction, Time Saving, and Reassign Employees. On the other hand, criteria: Frequency, Maturity, Availability, Transparency, and Reporting are lowered. He decided to lower and not completely removed the weight on the criteria that do not primarily focus on the achievement of business goals, because he also want to benefit from these other criteria.

Tabel 6 shows the effect of the new weight distribution (SD weights) on the total process outcomes. With a neutral weight distribution over all criteria the process would be scored in the following order: P4 + P6, P7, P11, P3. Here, P4 and P6 are scored equally. With the new weight distribution based on the Service Desk business goals, the processes are scored in order: P7, P6, P4, P3, P11. Score of process P4 and P11 where negatively impacted by the new weight distribution. This indicates that these processes have low scores on the criteria important to the Service Desk business goals, resulting in a lower score than with the neutral weight distribution. P7 increased the most compared to the neutral weights. Indicating that P7 has the most added value towards the business goals of the Service Desk.

By adjusting the weights to the SD weight distribution, the order of the processes changed. This new order shows the stakeholders which processes will contribute most towards their business goals. Without the use of weights, process four would be the best to implement together with process six. But now that we adjusted the assessment towards the service desk, process seven is the best option to automate, showing the impact of the weights to the score of a process.

Process	Neutral weights	SD weights	Difference
P3	2,27	2,35	+ 0,08
P4	2,67	2,55	- 0,12
P6	2,67	2,68	+ 0,01
P7	2,47	2,70	+ 0,23
P11	2,33	2,23	- 0,10

Table 6 - Weight effects on process assessment outcome

Some processes increased their scores with the new weight distribution, showing their importance towards the business goals. Others did not, showing that these processes are less relevant towards the business goals of the service desk. P7 has the highest increase in score compared to a neutral weight distribution, this implies that the process has a lot of improvement potential towards the business goals if RPA is implemented and scores high on the criteria that are increased in weight. This is also shown in table 5.

The effect of the weights on the process assessment is that by distributing the weights based on business goals, the process assessment results are influenced. Compared to a neutral distribution of the weights, the weight distribution of the Service Desk manager towards their goals caused all processes to result in different scores. Meaning that by distributing the weights according to the business goals, the assessment model will show the processes that will contribute most by increasing the process score outcome.

Trade-Off questions

To validate the trade off questions, we selected process three and applied process mining using the Celonis software. Process three was selected due to the process characteristics, it's the process with the highest frequency. This creates the likelihood that errors have occurred during the manual assessment that might be filtered out using process mining and thus gave the best opportunity to validate the effects of process mining. During the validation, we tried to measure as many criteria as possible using process mining and focused on the earlier discussed criteria: standardization, frequency, time saving, and availability. The data was extracted from the involved application and prepped for process mining in the Celonis software.

TQ1 – Does process mining decrease the amount of time it takes to complete the first and second iteration?

Table 7 shows the difference in assessment time of process three with and without process mining. The first iteration of the process was not impacted by the use of process mining, resulting in the same assessment time. This is because four out of five criteria from the first iteration are not based on process mining insights and therefore still require process knowledge and the analysis of existing documentation. With the addition of process mining, this was still the case. Except for standardization, which was extracted from the process mining instead of the existing documentation. This didn't impact the outcome nor the assessment time of the first iteration.

The second iteration however was impacted by the use of process mining. With the help of process mining, less time was being spend on tracking certain criteria over a longer period of time. Process mining was able to shows the assessor exact numbers on frequency, availability, and time saving, which had to be tracked by hand without process mining. This resulted in extracting the information from the process mining tool and filling the assessment model with it, saving the assessor around 35 minutes of tracking criteria over a five-day period.

	Without process mining	With process mining
First iteration	10	10
Second iteration	80	45

Table 7 - Duration of process assessment with and without process mining

Perhaps the biggest gains were made in the throughput time of the process assessment. During the assessment without process mining, a lot of information had to be tracked by hand in order to meet the measurement criteria of a five-day average. With the help of process mining, this five-day average could be calculated based on the data. This reduced the throughput time from five, to just one day.

The case study validation of our trade off questions show that with the use of process mining, the amount of time it takes to complete the assessment will decrease. Whilst in this case the time spend on the completion of the first iteration was not impacted – mainly due to the high process knowledge of the process expert –, the second iteration was greatly impacted by the use of process mining. In total, the assessment was reduced by 35 minutes or almost 40%.

The throughput time of the assessment of process three was also greatly reduced with the help of process mining. Because all data could be analyzed and extracted from the software, there was no need to manually track criteria measurements over a longer time period. This reduced the throughput time from five days to one day.

TQ2 – Does process mining impact the outcome of the assessment compared to the assessment without process mining?

Using process mining on the first iteration did not impact the outcome of the assessment. This is because the present documentation and process knowledge was equal to the process mining information.

The outcome of the second iteration was impacted by the use of process mining. The information gathered from the process mining data directly impacted criteria: Frequency, Time Saving and Availability. Which resulted in a change in criteria Efficiency, ROI, and Reassign employees. This is due to the connection between the criteria measurements and outcomes. The total process score also increased from 2,35 to 2,42. Appendix 9.17 Process 3 – Process Mining outcome of iteration 2 shows the differences in outcome, marked in yellow due to process mining.

The average process frequency increased from 151 to 152, mainly due to higher readings in the first three days based on the process mining data. This did not result in any changes to the criteria score but did impact the outcome of the total process time and reassignable FTE criteria.

The average TAT of process three came out higher than the manual tracking. Process mining data showed us that the completion of the process took 0.8 minutes on average, compared to the 0.5 minutes of the manual reading. This impacted the results of the reassignable FTE, total process time and return on investment.

The availability also increased from 480 minutes in the manual reading to 660 minutes using process mining. The data shows that cases in the process are being handled over a longer period of time than the process expert reported. Whilst all cases in the process should be finished before 5p.m., some cases where still being handled up to 8p.m. This decreased the possibility to increase the availability using RPA from 120 minutes to 0 minutes. Since the process was already active in these hours and thus cannot be increased. The decrease in added availability did not impact the score of the criteria.

As a result of the above criteria, other measurements where also impacted due to the connection with these changed criteria. Due to a change in average turn around time of the process, the total process time was impacted. This resulted in a higher FTE count needed to fulfill the model, thus impacted the reassignable FTE criteria. A higher amount of time being spend on the process means that the potential benefits for the ROI are also impacted.

Whilst all of the changes based on process mining outcomes only impacted the measurement outcome of a criteria and not the score of that criteria, the ROI criteria score increased from 3 to 4 due to the increase in benefits. This benefit increase – coming from a more accurate frequency and turn around time measurement – together with an unchanged cost of implementation resulted in a measurement increase of the ROI criteria from 62% to 125%. This new measurement outcome increased the ROI criteria score from 3 to 4, impacting the total process score by an increase from 2,35 to 2,42.

The use of process mining did not have an impact on the first iteration in this case study. Process mining did have an impact on the outcome of the second iteration. With the process mining insights, six of the fifteen criteria had changes compared to the manual assessment. Whilst for most of the criteria scores this did not result in a change, the ROI score did increase by one. This resulted in an over all increase of the process by 0.07 compared to the manual assessment outcome.

The use of process mining shows that it does provide benefits over the manual assessment. The measurements per process changed compared to the manual assessment which ultimately resulted in a different process score. Due to this new process score, process three is more suitable according to the model and thus becomes more attractive to the service desk manager. Process mining however could not support any other criteria measurement. Criteria like: Customer Satisfaction, Employee Satisfaction, Reporting, etc. still need to be performed via manual assessment.

Sensitivity questions

The sensitivity questions are answered by analyzing the outcome of the case study and also by a supportive questionnaire. The respond rate of the questionnaire was 100% and has a total respond of six management-level respondents from departments: IT, Service Desk, Finance, Marketing, Sales, and E-Business at Rexel Nederland.

SQ1 – Are there processes that could not be assessed using the assessment model?

During the case study at Rexel Nederland, all candidate processes could be assessed using the assessment model. All process owners and other key stakeholders where available for the assessment and participation during the case study. Due to the COVID-19 situation currently active at the time of writing this thesis, some appointments had to be re-scheduled, but this did not affect the ability to assess a process with the assessment model.

Some processes did take longer to assess because there was not enough documentation available, or the process was more complex. This often resulted in a longer assessing time. In the end, all process owners where able to assess a process on their criteria in both the first and second iteration.

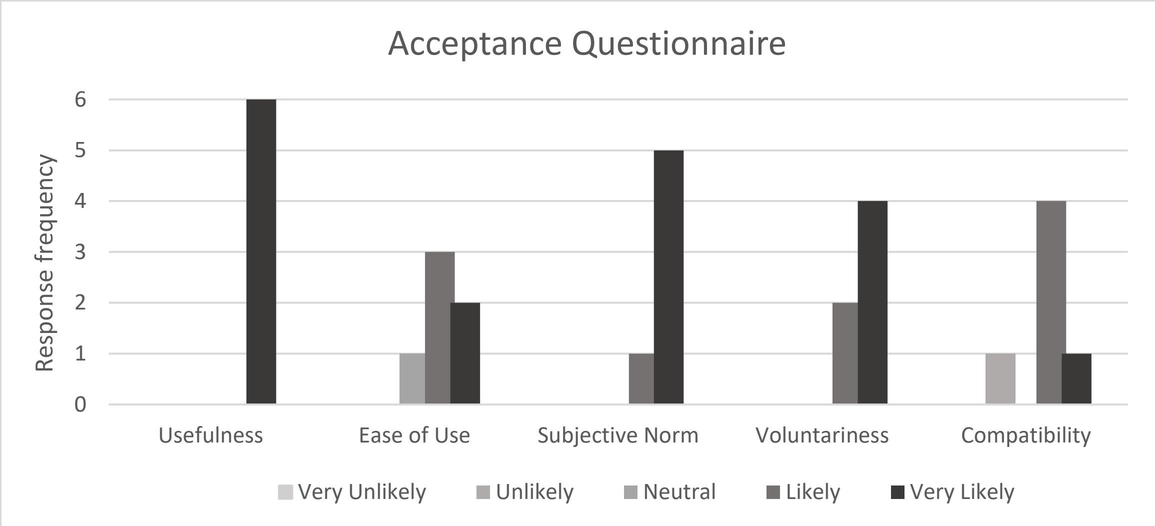
We therefore conclude that the model is applicable in different process ranging from simple to more complex. We did however only test fourteen processes on one department, which could limit the conclusion to this sensitivity question.

SQ2 – Would other departments at Rexel use this model for RPA process assessment?

To broaden the validation and validate the model outside just the Service Desk problem context, we used an acceptance questionnaire based on Riemenschneider et. al. [83]. The outcome of the questionnaire is illustrated in table 8, the x-axis corresponds with table 2 from page 74.

The results from the questionnaire show that all participants believe the assessment model will improve their RPA process assessment. The majority of respondents rate the Usefulness, Subjective Norm, Voluntariness high. Except for the Compatibility and Ease of Use where one of the respondents answered unlikely. Finally, we asked the respondents to leave textual feedback on the model based on their needs during RPA assessment and knowledge about the model.

Table 8 - Acceptance Questionnaire response



To understand the respondent's rationale, we look for further explanation in their contextual comments. Out of these, we identify the following as important points. First, because non of the respondents have great experiences with RPA process selection, "it can only get better" was one of the main reasons to score usefulness as very likely.

Second is the compatibility. Here the respondents had a more polarized opinion. Most reacted that the compatibility matches the strategy of Rexel and is consistent with past experiences. Most of the participants did note in their explanation that this is based on more recent projects. The respondent that scored neutral supported this by explaining that working in a very structured manner, with something like the assessment model, suits the strategy of Rexel well. However, according to him it does not support the current way of working. He stated that currently, most projects are not fully performed in a structured manner and will thus requires a switch in mindset when the assessment model is being used. The ease of use criteria also has, like Compatibility, one mention of a neutral score. The participants didn't leave any textual explanation to elaborate the given score.

Finally, we asked the respondents to provide additional feedback on the assessment model. Out of the four participants that provided feedback, three stated that it would be helpful if the model could provide additional information and feedback when processes are deemed unsuitable in order to adjust the process or look for other automatization options. One respondent requested to add dependencies between processes if applicable, so that the model can support two processes that are dependent on each other and so provide more information on the RPA implementation when both are automated compared to assessing them separately.

Based on the acceptance questionnaire we conclude that the model would be used by other departments for assessing processes on RPA suitability. All of the scores on all constructs are above neutral with only 1 answering neutral on the compatibility. This shows that the model is likely to be accepted by multiple departments.

Requirement satisfaction questions

In order to validate the requirement satisfaction, we analyzed the outcomes of the assessment and also interviewed our main stakeholder, the manager of the Service Desk. The combination of these outcomes are used to answer all four of the requirement satisfaction questions.

RSQ1 – Does the artifact assess a process on RPA technology criteria?
Looking back at our initial requirement and problem statement. This criteria is created so that the model will support the RPA process assessment. This process assessment consists of two criteria types, essential criteria and business criteria. Here, the essential criteria show the assessor if a process can be automated using the RPA technology.

After analyzing the outcome of the case study, the first iteration – which is focused on assessing a process on essential criteria – caused nine out of fourteen processes to fail. This shows that the assessment model does assess a process on its RPA criteria and by doing so filters out a lot of candidate processes that are not suitable for RPA implementation.

The service desk manager agrees with this analysis during the interview – appendix 9.9 Interview Service Desk manager for RSQ1 – RSQ4. He explains that the first process assessment improved his point of view on the processes and shows what processes are not suitable for RPA. He states that without this first iteration, using their traditional method, they would have definitely continued the RPA implementation with processes that failed the first iteration. Assuming these processes would fail during the implementation, the first iteration helped to filter out processes that are not suited and so saved Rexel time and money by not trying and failing an RPA implementation on unsuitable processes. We therefore conclude that the model satisfies the first requirement.

RSQ2 – Does the artifact provide the possibility to assess a process on business goals?
This requirement was created to fill the current gap in literature. As some experts mentioned, RPA implementation isn't always about the actual implementation of the technology or focused on just money. RPA is most likely to be used as a tool to meet certain business goals. Currently there are no assessment tools to our knowledge that can assess a process on the process criteria RPA implementation can have a positive effect upon.

This requirement will be satisfied if the model is able to assess a process on certain criteria that show the assessor the added value RPA implementation can have. Studies have researched the effects of RPA implementation on a business and process. We used these insights to extend to process assessment model and create a way to assess a process on criteria RPA can have a positive impact upon.

These business criteria are assessed in the second iteration, on processes that are suited for RPA implementation. The assessment of the processes on these business criteria is being done by specifically designed measurement options and translated to a criteria specific scoring scale. Via this second iteration, the assessor is able to assess a process on business criteria. Here, processes that score high – close to a score of five – have high potential to be improved by the implementation of RPA.

The assessor can use the weights to increase or decrease the importance of a business criteria. Increasing the weight of a criteria means that the assessor believes that by improving this criteria, the business goal will be met, or the improvement will contribute towards their business goals. In the case study, the goal of the Service Desk was to increase the employee satisfaction, reduce the time spend on the process by eliminating human error, and finally free-up FTE due to the high workload currently present at the Service Desk. These business goals were represented in the criteria weights by increasing the weights of criteria: Human Error, Efficiency, Employee Satisfaction, Time Saving, and Reassign Employee. Decreasing the weights of: Frequency, Maturity, Availability, Transparency, and Reporting.

As already discussed in table 6, this distribution resulted in a change of score for all processes and changed the order of importance. This resulted for some processes in an increased scores, indicating an increased importance towards the business goals, and for some process a decrease in process score, indicating a lesser contribution towards the business goals.

These case study results show us that by using a combination of business criteria and weighted scores, the assessment model is able to provide the ability for businesses to assess a process on their business goals.

This is also experienced in the same way by the Service Desk manager. During the case study, the manager is responsible for the distribution of weights in the model. He made sure that the business goals were represented in the model's weights. During the interview, we asked the Service Desk manager if he believed that the model provides the ability to assess a process on the business goal contribution.

The Service Desk manager agreed that the model is able to help business assess a process on the business goal contribution. He states that by distributing the weights over the business criteria, he was able to make sure that the criteria that would help him towards the business goals became more important over criteria that did this to a lesser extent. He extended on this by mentioning that he believes other departments would also be able to distribute the weights in such a way that they represent the business goals of RPA implementation. Both our case study analysis and the stakeholder feedback result in a satisfaction of this requirement.

RSQ3 – Does the artifact show what processes are suitable for RPA?

The main task of the assessment model is to show the assessor which processes are suitable for RPA and show to what extend these are contributing towards business goals. In the case of our assessment model, a suitable process is not only suitable for the RPA technology but also shows to what extend the RPA implementation will contribute towards business goals.

The outcome of the case study reveals that the artifact shows what processes are suitable for RPA. Due to the nature of the model, the first iteration has the biggest impact on this requirement. This is because the first iteration filters all candidate processes on RPA criteria extremes. If a process does not pass all of the first iteration criteria, it is deemed unsuitable. The case study shows that out of fourteen processes, nine did not pass the first iteration. Often, this was because one of the five essential criteria wasn't met by the process. Sometimes, a process would fail on multiple criteria.

Via the outcome of the first iteration, the model shows the assessor which processes are suitable for RPA implementation and which processes are not. However, this does not show the assessor which process is best suited to support the company's business goals. This is an important aspect of the model and something that is currently missing in literature and highly demanded. Just the first iteration outcome does therefore not satisfy this requirement.

The second iteration does not filter out any processes to deem them unsuitable. The focus of the second iteration is to score the processes that passed the first iteration to help businesses decide what processes to automate based on their business goal contribution after RPA implementation. The case study shows that the second iteration impacts the outcome of the assessment by scoring each process using a combination of business criteria and weights. On completion of the second iteration, the assessor can easily see which processes are most suited towards the business goals and what processes support this to a lesser extend.

The outcome of the second iteration shows that process seven – Specials from Non Alloc to Alloc– has the highest score and is thus most suitable for RPA implementation. Process eleven on the other hand has the lowest score and is therefore the least attracting to automate according to the business goals of the Service Desk.

We conclude that based on the case study outcome, the assessment model can show what processes are suitable for RPA implementation. With the first iteration, the model shows which processes are suited to be automated via RPA. The second iteration shows the assessor from these remaining processes, which processes are best suited to automate in order to contribute towards the business goals. This way the assessor is able to spot which process is best to automate at the end of the assessment.

The Service Desk manager also agrees with our conclusion based on the case study outcome. He states that the artifact shows him what processes are suitable for RPA implementation via the first iteration and also shows him which processes will contribute most towards his business goals via the second iteration. The service desk manager states that he is able to select the best processes that will help him reach his business goals. We therefore conclude that the model fulfills this requirement in its problem context.

RSQ4 – Does the artifact supports process mining in a voluntary way?

Research indicates that process mining can greatly improve process assessment for RPA. However, our main goals was also to create an assessment model that can be used by any company and in any situation. We therefore researched the potential benefits of process mining on RPA assessment and added this as an optional improvement for companies that have access to this technology.

Based on the case study results, we can see that the use of process mining compared to manual assessment does impact the outcome and throughput time of the assessment. With the use of process mining, certain criteria measurements can be completed in less time and with more accuracy, as also stated in literature.

However, the assessment model can still be used without the need of process mining. As the case study shows, all processes could be assessed without the need for process mining. Whilst this does increase the amount of time the assessment takes, increases the throughput time of the assessment, and possibly reduces the accuracy of the measurements, non of the processes are unsuitable for assessment without process mining.

There where also no major changes to the assessment model outcome that in our opinion makes an assessment without process mining unreliable. This makes process mining a valuable option to increase the accuracy of the model and decrease the amount of time that needs to be spend on the completion of the model for businesses that have access to this technology.

During the interview, the Service Desk manager also agreed on our process mining analysis and states that requirement four has been satisfied in the model. He states that even though the use of process mining changed the outcome of the assessment, the model can still be used in a reliable way without it. The process mining technology does show to improve the assessment, but to him this is not in a way that it becomes mandatory for a good assessment of the process.

We therefore conclude that process mining can be used in a voluntary way to improve the assessment of a process but is not required to complete process assessment in general. Thus, the model satisfies requirement 4.

5.3.2. Discussion

The results of the case study indicate that the assessment model works as designed in its problem context and fulfills all requirements. This has been demonstrated in the previous results chapter and validated in the case study and interviews with the key stakeholders. However, during the case study there have been some points of interest we like to highlight based on the outcome of the case study:

1. The case study was conducted during the summer period. This resulted in less than usual volume for the Service Desk department. This resulted in lower process frequency than normal and thus also reduced the change of human error and lowered the frequency criteria in comparison to a 'normal' business week. Whilst this might have impacted the individual outcome of a process suitability, all processes were assessed over the same period. Therefore, making the final conclusion still relevant between processes.

2. We experienced low amounts of reported human error. According to the Service Desk manager, this is really dependent on the employee performing the process and overall pressure on the employee. Whilst the measurements are correct and do represent the measured period, it is possible that the outcome would have been different when there was more overall volume of work at the Service Desk, or another employee would have performed the process.

3. The criteria: frequency, efficiency, availability, and reassignment of employees all have equal scores in all processes assessed in the second iteration where other criteria had different scores over all assessed process in the second iteration. There is a difference between the process measurements per criteria, but this was within the scoring scale range and therefore didn't impact the criteria score. Whilst this can be a valid score and just be limited due to the small sample size of five processes, it could also be a sign of an unsuitable measurement scale for those criteria. As stated in the design of the measurement scales, we support future research on this topic.

4. During the validation on process mining, we concluded that the throughput time decreased from five to one day. Whilst this was true during the case study, other manual measurements can still increase the throughput time. The Employee Satisfaction for example could increase this if businesses decide to perform the ESI via online surveys. Other information coming from sources outside the direct stakeholders group can also increase the throughput time, even with process mining.

5. Whilst the differences between results after process mining where not very large during this study. Depending on the situation and manual assessment of the process, these differences can be greater than shown in our case study. Our results also didn't show any change in iteration one, due to the small sample size we are not comfortable concluding that process mining will never have an impact on the first iteration. To get a better picture of the potential impact and added accuracy process mining van have on the assessment iterations, more comparisons need to be made between manual assessed processes and assessment using process mining.

Whilst these limitation where present during the case study, we still deem the case study relevant and successful. The goal of the case study was to validate the assessment model in its problem context. The case study supported this goal and showed us how the model worked in practice. According to the Service Desk manager and acceptance questionnaire outcome, the assessment model provides stakeholders with relevant information and helps to assess a process on RPA suitability.

In order to overcome the above points of interest, future research case studies can be conducted in other companies with more available test cases over a longer period of time. Combined with future research on the scoring scale, the limitations can be overcome. These points where deemed out of scope for this thesis.

6. Discussion

In this section we will discuss the outcome of the thesis in regard to the gaps found in chapter 1 and discuss the results and relation to current and future literature.

6.1. No complete checklist for process assessment

As stated in the introduction, there is currently no sufficient assessment model that combines al important criteria into one model for a complete RPA process suitability assessment. Most of the currently available models either focus solely on technical assessment or focus the assessment on the added value of RPA on a certain key benefit. This creates a gap in literature and a desire for a model that can assess a process on all aspects [6], [11], [53]. As shown by Rexel Nederland, assessing a process on insufficient criteria can create the idea of a complete assessment. However, when implemented, this often doesn't seem to be the case. Resulting in failed implementation or dissatisfaction to fulfill the implementation goals.

In order to address this issue, the assessment model will combine two types of criteria: essential and business criteria. By doing so, the assessment mode provides the opportunity for businesses to get a complete assessment of their processes before implementing RPA. We accrued these criteria via the literature review, which resulted in a list of seventeen criteria important to RPA process suitability assessment.

The case study results validate that all these criteria can be measured in a process and result in the ability to assess a process. The biggest impact during the assessment is the assessment on essential criteria. The case study results show that here, nine out of fourteen processes were rejected and deemed unsuited. The second iteration shows that the assessment model can help to distinguish the processes according to business goals and impact.

However, because this study is based on literature review, we cannot rule out the possibility of missing criteria in this model. During the case study, there was no sign of any missing criteria to assess a process upon or translate the business goals towards. This could be because the list is complete or due to the small sample size. With many developments in the RPA sector, like the addition of AI with RPA, we cannot determine the completeness of the checklist. We do conclude that based on the currently available literature and case study outcome, the list is able to assess a process on both essential and business criteria, without any signs of missing criteria during our case study. Filling the gap that is currently present in literature.

6.2. Process suitability identification

One of the main challenges currently present during RPA implementation projects is the assessment and selection of the right processes for RPA implementation. A wrong process assessment can often lead to failed projects, higher cost and other obstacles [9], [11], [21]. To address this issue, we created a new process assessment model with the incorporation of essential and business criteria, as well as optional process mining support.

The results of the case study show that the assessment model is able to assess a process on its RPA suitability. With the process scores, the assessor is able to spot the process suitability and so identify which process is best to automate using RPA. This has been confirmed by the participants of the study, who agree with the outcome of the case study analysis. They agree that the model is able to identify processes that are suited for RPA implementation and also add to what extend they contribute via the process scores derived from the business assessment iteration.

The case study results also confirm the statements that process mining can improve the assessment of processes on RPA suitability found in literature [18], [20], [42], [62]. The case study shows that process mining does improve the accuracy of the assessment and also helps to decrease the amount of time it takes to complete this. The case study result show that compared to the manual assessment, the process mining data showed different results. Even though these results are not very big and only tested on one process, we still conclude that the assessment with process mining helps to increase the accuracy and reduce the throughput time of the assessment.

6.3. Business criteria for process assessment

One of the main missing elements in the current RPA process assessment models is the inclusion of business suitability assessment. As stated by Wanner et. al. "*A process or tasks can be judged by its impact or importance to the business. This is where literature does not provide a clear outline".* This is also seen in the currently available RPA assessment models. Most of these models are very narrow focused on one specific RPA benefit, or only assess a process on the technical suitability. In line with the future work suggestions from multiple studies and the example of the failed RPA implementation of Rexel, we addressed this issue by creating business criteria.

Based on available literature on the benefits RPA implementation can have on a process, business criteria where created. These are the criteria that are not essential for a process to have in order to be able to implement RPA, but rather measure the improvement potential RPA can have after implementation. By adding these criteria to the existing essential criteria for RPA implementation, we created a way for business to assess a process on its business importance and impact, as suggested by Wanner et. al.

The case study results highlight the impact of these criteria on the process assessment. With the combination of weighted scores and specific measurement options, the case study stakeholders where able to assess their processes on the business goal impact. This is highlighted by the impact of the second iteration and shows that after the assessment on business criteria, there is a clear distinction in importance between the processes, expressed in the process score.

As suggested and anticipated by other studies. The outcome of the process assessment is impacted by the use of business- related criteria measurements as shown by the case study results [9]–[11], [13], [15], [20], [26], [29]. However, to see the exact impact of the business criteria, one should implement RPA on these processes. This will showcase the actual impact and preciseness of the criteria in practice. We where not able to test this due to our scope limitations.

Contrary to the overall results of the business criteria in the assessment model, we see that some business criteria do not impact the final outcome of the process score in our case study. This is because the scores on all case study processes are equal for these criteria. In order to validate their use in the assessment model, a larger sample size should be used. This will increase the likelihood of a different score for these criteria and so showcase their value to the assessment model in practice.

7. Conclusion

This section of the thesis elaborates on answering the research questions followed by a recommendation section for future studies and contributions made by this study.

During RPA implementation projects, the assessment of processes on the suitability of RPA is an important and difficult step. It is also known as the biggest challenge during RPA implementation projects. With 30 to 50 percent of all RPA projects failing and the RPA sector expecting to have significant growth over the coming years, there is a need for a good process assessment method. As demonstrated by our supporting company and shown by the results found in literature, the currently available methods are not effective enough and still result in wrong process assessment for RPA.

This thesis aimed to address this problem by improving the RPA process selection via the creation of a new assessment model. The goal of this model was to fill the gap currently present in literature and so reduce the amount of failed RPA implementations due to insufficient process assessment. In order to do so, the model had to be able to counter the problems that are currently present with process assessment for RPA being: Literature does not support outlines to assess a process on business importance, the assessment is unable to identify business value of RPA implementation, and no complete assessment model is available that covers all aspects of RPA suitability. This was translated to our research question: How can you assess a process on its RPA suitability, whilst also taking business goals into account?

To address this, we used the design science methodology for this thesis. By using this method, we ensured that the creation of an artifact – the assessment model – would be created via a widely approved method. We found that this method was very effective in supporting the creation of the assessment model. The thesis started with a literature review in order to find answers to our knowledge questions. During the literature review of this thesis, various criteria related to RPA where extracted form literature and combined to form the core of the assessment model. Here we found that a selection of essential criteria and business criteria for RPA. The essential criteria are focused on process characteristics that need to be present in order to implement RPA, where the business criteria are focused on the known benefits RPA has on a process after implementation.

To assess a process on these criteria, we designed measurements and scores for each individual criteria. We sometimes encountered a lack of information during the creation of the scoring scales which let us to design our own scoring scales. Because we wanted the model to be applicable for all companies but still be relevant in all situations, we designed a weighted scoring mechanism in the model that users can tweak according to their business goals. Allowing for a generalized model that can be tweaked to specific situations using criteria weights. To improve the assessment, we also incorporated option process mining support to the model.

The designed artifact theoretically satisfied all requirements but still needed a form of practical validation. This is because the model is designed to be used in actual process assessment projects and thus needs to be practically validated to see its value in the problem context. This was done via a case study at Rexel Nederland.

The outcome of the case study showed that by completing the process assessment using the designed assessment model from this thesis, we where able to assess multiple processes on their RPA suitability and business goal contribution. Resulting in a ranked list of processes that where suitable for RPA implementation and scored according to their business goal contribution.

7.1. Limitations

The thesis results provided evidence that the created assessment model fills the current literature gap and provides a way for businesses to assess a process on RPA and business goal suitability. However, there are some limitations to acknowledge regarding the design and validation of the model. By doing so, the findings of this thesis can be assessed in a more critical way. Whilst some limitations where unintended, some are intended due to the chosen scope of the thesis.

One of the limitations of this study is its relatively small sample size of just one company. Whilst a great part of the assessment model is based on existing literature and also criteria that have been tested in multiple scenarios and case studies. Our assessment model has only been tested at Rexel Nederland. A larger sample set, such as one over various companies, sectors, and departments, might change the outcome and usefulness of the model. This could provide new insights to the use of the model and validate its use in different scenario's.

During the validation of the model, some criteria resulted in the same score over all case study processes. It is therefore unclear to validate the effectiveness of these measurements and find the cause of these scoring results. Having a same score on all processes can be due to the small sample size or a wrong scoring scale design. As stated earlier in the design chapter of this thesis, we where unable to create all scoring scales based on existing literature. This resulted in best effort scales based on limited data and testing.

Finally, the study has been limited by its time and scope when it comes to the final process score. It is beyond the scope of this thesis to actually implement RPA in the candidate processes. We where therefore unable to validate in practice if all 'unsuitable' processes where actually unsuitable for RPA implementation and vice versa. Although all criteria have been validated in practice, the outcome of the assessment model can in theory still be different from the actual implementation of RPA in that process.

7.2. Future Work

There are several suggestions for future work to extend on our research and improve the assessment model based on the limitations. First, we suggest testing the assessment model using a greater sample size covering multiple companies in different sectors that have different goals. By doing so, the assessment model can be validated based on various scenarios to see its effectiveness and expand the knowledge on the model, potentially providing valuable information to improve the assessment model.

To improve and validate the scoring scales, we suggest future research on this topic. Some of the measurement scales are not embedded in literature and could therefore be inaccurate. To improve the model on this section, we suggest specific analysis on possible scoring scales for each criteria. This can be done via data analysis or case studies.

We finally also suggest testing all candidate processes throughout the RPA implementation lifecycle to see if the outcomes of the models coincide with the actual implementation of RPA. By doing so, research can validate if the assessment model provides a valuable assessment in regard to the complete RPA implementation lifecycle.

In terms of broadening the scope, it would be interesting to consider the use of other technologies in the model. Our model supports the use of process mining as a supportive technology to improve the assessment of process. Other technologies like Artificial Intelligence and Machine Learning are also becoming increasingly popular in the field of RPA. These technologies open up multiple possibilities to support the process assessment and increase its accuracy.

Some RPA vendors are also combining Artificial intelligence and Machine Learning with RPA to extend the use case of RPA. However, this is currently not a mainstream approach. If RPA, ML, and AI are combined in the future, the assessment model will likely need to be adjusted to suit the criteria necessary to assess a process on its suitability. Future work can extend this research using these new technologies in their scope and so update the model to meet the new criteria that arise with developments in the field of RPA.

7.3. Contribution

The thesis has made both scientific contribution via the answer to the knowledge question about a literature gap and also created practical contribution for businesses that are of are going to implement RPA. This chapter will elaborate on these contribution.

7.3.1. Scientific contribution

This thesis provides a way to assess a process on its RPA suitability and contribution towards a company's business goals to address the desire of an RPA assessment model that assesses a process on business goal contribution. Whilst most of the current models are to narrow focused to create a complete assessment on RPA suitability, our created model provides the criteria and measurements to perform a complete assessment of a process on its RPA and business goals suitability.

Though the use of business criteria in RPA assessment models have been suggested in recent studies. No assessment model has incorporated these. We validated our assessment model and concluded that it is possible to assess a process on business goal contribution of RPA. Future studies can now extend on this knowledge. We also confirmed suggestions from existing research that process mining can support the RPA process assessment. This thesis concludes that both these statements are true and shows how process mining can be incorporated in RPA process assessment.

7.3.2. Practitioners contribution

With a large portion of the current RPA implementations resulting in failure, this study provides a solution organizations can use to assess their processes on RPA suitability. The assessment model will help practitioners to assess a process on its RPA suitability and business goal contribution. Ultimately resulting in less failing RPA implementations for current and future users of this technology. Using this model, organizations can support their process selection based on data and scores, resulting in an evidence-based decision for RPA implementation.

Current and future practitioners can use this model to improve their RPA process selection. Tweaking the model to their specific situation and also optional involving the use of process mining to improve the accuracy of the model. Ultimately reducing the change of failed RPA implementation projects with the help of this assessment model.

8. References

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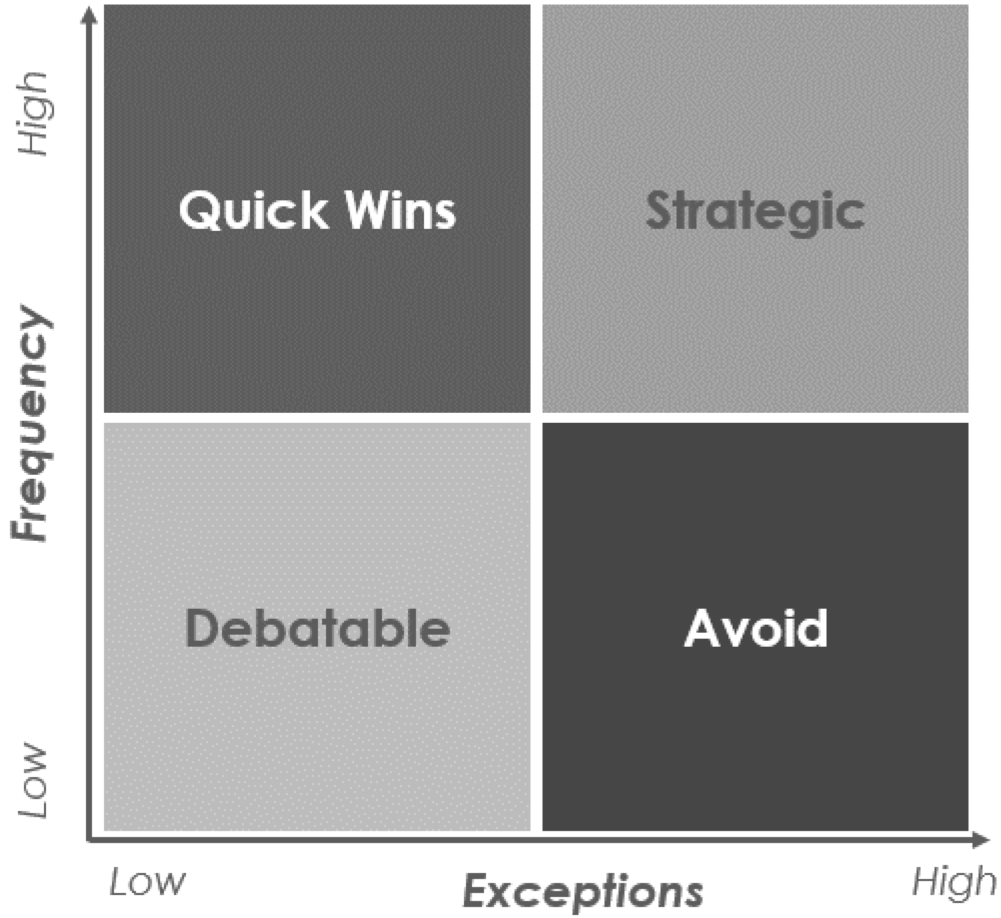
9. Appendix

9.1. RPA assessment by Rexel



9.2. First iteration of RPA criteria

Table 9 - First iteration of RPA criteria

Criteria	Source	Definitions
Standardization		
	Wanner	Streamlined process tasks with a good knowledge of possible events and outcomes of executions.
	Santos	the more standardized the process is, the fewer exceptions happen. Having not many exceptions to handle is a key factor, because having a lot of exceptions makes it time-consuming for the robot to automate.
	Lacity	all of the company's business units expect the same service.
	Kroll	Just mentioned standardized
	Aguirre	Limited exception handling
	Hofmann	Just mentioned standardized
	Devarajan	Simplify and small number of exceptions
	Wellmann	The number of exceptions to the main flow of the process. Processes with low amounts of exceptions are better RPA candidates.
	Kaya	Should be rules based and standardized, with small number of exceptions
Frequency		
	Wanner	Task should be repetitive and in high transaction volumes
	Santos	High transaction volumes
	Lacity	High transaction volumes
	Aguirre	RPA is more suitable for high volume standardized tasks that are rules driven, where there is no need for subjective judgement, creativity, or interpretation skills.
	Hofmann	Repetitive tasks
	Wellmann	The potential is higher when more systems are involved. Robots outperform humans in atomic operations like copy and paste.
	Leshob	The volume of transactions is defined as the average number of transactions performed per day
Number of involved systems		
	Santos	Having a bot work with multiple systems often increases the potential benefits of that implementation
	Lacity	Transferring data from multiple input sources like email and spreadsheets to systems of record like Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) systems
	Kroll	Processes with regular workload peaks that require access to multiple systems seem to be of current, Processes that require access to multiple systems can be an RPA criteria

	Aguirre	Transferring data from one system to another
	Wellmann	Number of systems involved
	Kaya	RPA might require multiple system access to implement.
Data quality		
	Santos	The data must be correct, so that the robot does not make mistakes and must be available digitally, to be accessible to the robot.
	Aguirre	The data must be structured.
	Hofmann	The data must suit the type of robot you are using. Structured vs unstructured data must fit with the datatype the bot can work with
	Tornbohm	Robotic process automation (RPA) tools perform "if, then, else" statements on structured data
	Syed	All data must be digital. The quality of input data is emphasized as an essential ingredient for RPA success. Input data must be consistent, not contain 'surprising' null values, and in general be carefully defined. This is one reason why processes which have lower quality of input data are deemed unsuitable for RPA and/or only those with strict controls in place of the received data are recommended for RPA. Currently, another major constraint for successful RPA deployment is the mandatory requirement for structured data
	Accenture	The process must involve only structured, digital input (in some cases, other automation tools may be needed to prepare data for processing by software robots).
	Jalonen	It could be said that the input data quality is the main source of benefits in RPA. If the data is consisted, does not contain surprising null-values, and in general the inputs are carefully defined, RPA implementation can be really successful. But if the input data is not consistent and often contains either logical or semantic errors, the robot can behave in unexpected ways.
	Wellmann	The data perspective resembles the structuredness of data. If a robot shall process data, the data source must be digital. Moreover, the data must at least be semi-structured to enable automation. When a process involves handling data, users may perform simple operations to extract it from the source and enter it into a system. This is a crucial requirement for the successful interpretation and execution of process steps. To evaluate this criterion the data source is analyzed. Typically, structured data is in semi-structured forms like spreadsheets, websites, or emails. Unstructured and hardly accessible data impedes RPA.
	Kroll	The data must suit the type of robot you are using. Structured vs unstructured data must fit with the datatype the bot can work with.
Maturity		
	Wanner	Low probability of exception and high predictability of outcomes. Not very subjective to major change in the future.

	Santos	When systems change, sometimes the robot must be reconfigured, which is costly and time consuming
	Wellmann	Maturity indicates that no frequent changes to the process flow are observable.
	Lacity	Mature processes are easier to move because they are measured, well-documented, stable, and predictable and their costs are known.11
Human error		
	Santos	Tasks that are prone to human error are suited for automation because it allows the reduction of costs and the increase of performance, as robots do less mistakes than humans. Also, tasks with no need or limited need for worker intervention and low cognitive requirements are an important aspect because robots lack analytical and creative skills. Without the intervention of humans, the complexity of the process would increase.
	Lacity	A robot performs a task different from a human. A Robot needs more rules and therefore follow these rules and won't make a mistake where a human could.
	Kroll	RPA can work faster than a human, and will make fewer mistakes on mundane tasks, where processes are complex, yet highly rules-based, and employees are subject to losing concentration.
	Wellmann	Humans tend to erroneous behavior when executing monotonous and voluminous tasks which results in such errors. Eliminating those can save time and cost.
	Wanner	Activities with high failure rates are good RPA candidates. Bots make less errors thus will improve these processes.
	Aguirre	Tasks that are prone to human error are suited for automation to reduce cost and improve efficiency
Return on investment		
	Lacity	Implementing RPA can have a fast return on investment compared to BPMS
	Hindel	Implementing RPA can lead to a considerable ROI
	Siguroardottir	ROI = ((total benefits - cost)/ cost) * 100 typical benefit factor used to measure ROI for RPA projects is FTE savings. Typical cost factors: Software Robot (license cost), number of robots, Training people in RPA (FTE cost), RPA team (FTE cost): Project manager, Process analyst, Developers, Process owner, Process experts, Application owner, and IT infrastructure (SQL server, application server, FTE cost, etc.)
	Devarajan	Reducing the cost of a task can often be achieved by implementing RPA

	Kaya	Before automation, a Business Process Outsourcing (BPO) service provider, one that handled the application for processing insurance benefits employed a full-time human employee who could complete the process in an average of 12 minutes. Automation software completed the process in one-third the time, tripling the transaction volume for one-tenth of the FTE cost.
	Wanner	Half of the experts considered idea of the return of investment as the core of the successive processing. Wanner uses 4 variables to determine the economic return on investment using: Variable labor cost, fixed labor cost, fixed cost of RPA and variable cost of RPA
Employee satisfaction	Goris	Process is performed by the RPA software robot, while the more complex tasks are still performed by a human employee. This will increase employee satisfaction
	Kroll	RPA taking over tasks can minimize the stress curve, having a positive effect on both employee satisfaction and health
	Wewerka	As a positive effect of RPA on employees, the latter are relieved from non-value adding tasks and, consequently, they become more satisfied
	Hindel	As a result of RPA employee satisfaction could be improved
	Siguroardottir	RPA makes redeploying employees to more important task possible, increasing their satisfaction
	Devarajan	RPA can relieve employees of repetitive mundane tasks, so they can focus on more engaging and challenging activities. Most employees have better morale when they invest their time and talent in jobs that are more interesting and less routine
	Hofmann	Internal benefits of RPA include the higher satisfaction of employees
	Leshob	allowing organizations to relieve their employees from repetitive and tedious tasks
	Wellmann	increases time for employees to focus on more value-adding tasks
Process quality	Goris	processes that need high quality and accuracy are good RPA candidates
	Santos	Compared to humans, robots make less errors and work faster with more quality,
	Kroll	Better mean time to respond: Hours to Minutes and Minutes to Seconds Significant reduction in error rates
	Wewerka	RPA eliminates human errors, improves accuracy
	Aguirre	RPA follows rules and always acts the same, increasing the quality

	Siguroardottir	Many automated systems have this in common: taking out the most unreliable factor (human error) thus improving precision, quality, and accuracy.
	Wellmann	Companies use RPA to improve the quality of their work, eliminate human negligence and increase reaction time around the clock
	Devarajan	RPA enables businesses to streamline and standardize their processes which reduce errors
	Kaya	Nature of human work includes error. Risk of malfunction, error and fraud in manual systems are always higher than automated systems. Robots are trustworthy, consistent, and tireless. They can perform the same task the same way every time without error or fraudulence.
Time saving		
	Goris	Not only to quality of the output of the process should increase by reducing the errors, but the speed at which the process is performed will be increased as well. Software robots are able to work 24/7, providing reliability and continuity of service
	Lacity	For some processes, it reduced the turnaround time from days to just minutes
	Santos	A robot can perform the same task faster than a human can do the same tasks, thus making is faster
	Kroll	RPA can safe up to 70% of the total time of a task/ process by automating tasks and reducing errors
	Wewerka	Automated processes run faster, and case duration becomes shorter
	Wellmann	The time consumption of a task/ process can be lowered by implementing RPA.
	Hofmann	Turnaround time will be decreased by using RPA
	Leshob	RPA is suitable for processes that consume a considerable amount of time and has the potential to lower the cycle time
	Aguirre	One robot can perform multiple tasks at the same time
	Wanner	Not only activities that are executed frequently provide a high saving potential, but also activities that are time consuming. Hence, we consider the average duration of an activity during a process execution.
	Kaya	Decreased cycle times, improved throughput, and efficiency
Availability		
	Goris	Processes that need to be available at all times are good RPA candidates
	Kaya	Unlike humans, robots can perpetually work 24 hours a day and seven days a week
	Kroll	Bots are available 24/7, making it possible to use the saved employee's hours in various different places bots are not active

	Wewerka	RPA gives you more availability of the tasks/ process, because the bots can work more hours than human employees can
	Jimenez-Ramirez	Continuous work capacity
	Hindel	RPA provides the benefits or more flexibility and availability due to it being available 24/7 and can be programmed to fit almost every need
Efficiency		
	Santos	This type of automation aims to automate business processes with the goal of improving efficiency while cutting costs, by reducing the time humans spend dealing with Information Systems, doing repetitive tasks, such as typing, extracting, coping and moving huge amounts of data from one system to another system, meaning that these structured and manual tasks can be done by a robot.
	Kroll	Essential quantifiable measures of success include (...) process efficiency. 86% of users believe that RPA helps increase the efficiency
	Hindel	Literature emphasizes and increase of efficiency
	Aguirre	The goal or RPA is to automate structured tasks in a fast and efficient manner
	Wellmann	RPA minimizes manual work and increases efficiency at the enterprise's bottom line.
	Leshob	RPA offers increased business efficiency
	Kaya	An enterprise user of an IT infrastructure automation tool suite that was designed to work with existing investments improved its overall operational efficiency by cutting its mean time to resolution by 60 percent and by handling over half of its IT problems without manual intervention. Additionally, RPA will reduce the need for routine support effort. With RPA, labor costs will decrease and efficiency of IT personnel will increase. RPA will especially improve error-free and accurate transactions in accounting and increase the efficiency and effectiveness in monitoring and auditing transactions.
Reassign employees		
	Santos	RPA allows employees to focus on more value adding tasks
	Siguroardottir	Multiple companies have proven to be reassigning employees after the RPA implementation
	Kaya	If experienced enough, people in a company can be assigned to configure RPA robots. Or just being freed from routine tasks and being able to focus more on core business objectives and operations.
	Wewerka	

	Hindel	Moreover, significant time savings are named as another benefit of RPA. This aspect allows employees to refocus on more exciting and high-value tasks such as innovation and customer service. As a result, both employee and customer satisfaction can be improved.
	Wellmann	Last, the execution time of a process is a criteria to assess the suitability of processes for RPA. Decreasing the time spent with repetitive and highly transactional jobs, increases time for employees to focus on more value-adding tasks.
	Devarajan	RPA can help in resolving low priority queries and lets human employees focus on high priority service issues.
	Hofmann	Companies need to rethink employee roles after RPA implementation. They can be saved, used in other sections of the company, or used together with RPA
Customer satisfaction		
	Wanner	Enabling companies to free up resources and to reallocate them to activities with a focus on creating business value and customer satisfaction, RPA can foster the emergence of new work forms and drive organizational competitiveness in the digital age.
	Lacity	By improving the process speed, the customers will be helped better and more consistent. This should improve customer satisfaction; however, this has not been measured but is very likely.
	Siguroardottir	Increased customer satisfaction (internal and external) by lowering the error rate and faster execution time
	Devarajan	It is a way of creating a virtual workforce that brings in extended capacity to businesses to gain a competitive edge in customer satisfaction and enterprise agility. RPA can help in resolving low priority customer queries and lets human employees focus on high priority customer service issues. Most employees have better morale when they invest their time and talent in jobs that are more interesting and less routine.
	Hindel	By improving the process/ tasks, customer experience is likely to increase. This will be a result of RPA improvement.
	Kaya	Implementing RPA on certain points can help business improve on customer satisfaction by reassigning the employees
Transparency		
	Devarajan	RPA bots can detect poor data integrity errors and enable standardization. This leads to transparency in any industry by identifying significant errors hampering both management decisions and operational performance. RPA Bots execute processes per instructions they have been configured to follow and provide an audit trail for each step. Furthermore, if any step in a specific process needs to be reviewed, bots have ability to play back their actions. This controlled nature of bots increases transparency and eliminates fraud.

	Leshob	By increasing the amount of robotization, processes and tasks are performed via set rules with little to no possibility of exceptions. This will increase the transparency of the process.
	Anagnoste	By tracking the bot it's logs the process gets a lot more transparency. Besides just the logs, documentation of the RPA process-steps is also a common benefit of implementation.
Reporting		
	Devarajan	RPA generates significant amount of data that allows organizations to analyze and identify process bottlenecks / inefficiencies. This operational insight provided by bots allows organizations to streamline existing business processes.
	Kaya	Multiple reporting possibilities arrive with the use of RPA. The bots log a lot of data that can be used to analyze the bot's behavior or to optimize the process
Rule based		
	Leshob	Activities must be based on predefined. Or clearly definable, business rules.
	Anagnoste	RPA technology follows a pre-defined set of rules for any company willing to adopt it.
	Aguirre	Robotic Process Automation (RPA) emerges as software-based solution to automate rules-based business processes that involve routine tasks. RPA is more suitable for high volume standardized tasks that are rules driven, where there is no need for subjective judgement, creativity, or interpretation skills.
	Lacity	RPA can only work on processes that have clear rules that must be followed during the execution.
	Fung	This server process is viable because workflows can be programmed to turn all network-connected idle servers into standby mode based on certain rules.
	Geyer	The virtual bots are integrated in existing software and repeat tasks, often across multiple systems. Their configuration is driven by simple rules and business logic. RPA unfolds its maximum potential on rule- based processes

9.3. First iteration of RPA criteria measurements

Table 10 - First iteration of RPA criteria measurements

Criteria	Source	Measurement per source
Standardization		
	Wanner	Measure inverse standardization by analyzes each activity in a given process instance and returns the number of different prior and following activities
	Santos	Measure the number of exceptions in the process
	Lacity	Not present
	Kroll	Not present
	Aguirre	The amount of required exception handling
	Hofmann	The number of exceptions
	Devarajan	Not present
	Wellmann	Number of variations to the execution flow in businesses
	Kaya	Not present
Rule based		
	Leshob	Based on predefined business rules that can be clearly defined
	Anagnoste	Predefined set of rules before implementation about the process
	Aguirre	Not present. Being able to define the process in rules
	Lacity	Not present. Being able to define the process in business rules
	Fung	Automate business rules with logical flows
	Geyer	Use rules and business logic
Frequency		
	Wanner	The count of each activity belonging to the same process.
	Santos	The number of repetitions of the same process
	Lacity	Number of repetitions per week
	Aguirre	Not present
	Hofmann	Not present
	Wellmann	Number of activity's occurrences in a certain period. His research used one day
	Leshob	The average number of transactions performed per day
Number of involved systems		
	Santos	Multiple systems involved in the process
	Lacity	Not present
	Kroll	The number of used systems to complete a process

	Aguirre	The number of systems the process requires access to
	Wellmann	Number of systems involved
	Kaya	Number of involved systems
Data quality		
	Santos	Digitally available and accessible to the robot
	Aguirre	Available data type (structured) and online data availability.
	Hofmann	Data type (structured/ unstructured)
	Wellmann	Analyzing the data source to evaluate the structure and if it is digitally available. Consistent use of data objects
	Kroll	Optimized input data for RPA
Maturity		
	Wanner	Avoid rework due to process change
	Santos	Stable process
	Wellmann	Number of changes to the process over time
	Lacity	stable and predictable process
Human error		
	Santos	The number of errors in the process
	Lacity	Not present
	Kroll	The amount of error in the process
	Wellmann	The number of human mistakes and the time to fix those
	Wanner	The amount of time activities are repeated due to errors
	Aguirre	Not present
Return on investment		
	Lacity	Number of saved or redeployed FTE cost versus cost of RPA
	Hindel	Not present
	Siguroardottir	**((Total benefits - cost) / cost)** || Benefit = FTE reduction || Cost = RPA bot license + RPA implementation project cost + Training + IT infrastructure cost
	Devarajan	Not present
	Kaya	Not present
	Wanner	((Total benefits - cost) / cost)
Employee satisfaction		
	Goris	Reduction of repetitive tasks
	Kroll	Interviews

	Wewerka	Reduction of non value adding tasks
	Hindel	Reduction of repetitive and tedious tasks and focus on more exciting and high-value tasks
	Siguroardottir	Reduction of boring tasks and allocation of new tasks
	Devarajan	Not present
	Hofmann	Not present
	Leshob	Reduction of repetitive and tedious tasks
	Wellman	Not present
Process quality		
	Goris	Reduction of errors in the process
	Santos	Lowering errors
	Kroll	Not present
	Wewerka	Reduction of errors and improvement of speed
	Aguirre	Based on general improvements by RPA implementation
	Siguroardottir	Reducing the number of errors
	Wellman	Not present
	Devarajan	Reduction of errors and more standardization
	Kaya	Reduction of errors and possibilities of fraud
Time saving		
	Goris	Time it takes to complete the process
	Lacity	Turn around time (TAT): Time interval from the time of submission of a process to the time of the completion of the process
	Santos	Time it takes to execute a task
	Kroll	Time it takes to execute the process
	Wewerka	The duration of process execution
	Wellman	The duration of a process expressed in time required to execute a process
	Hofmann	Turn around time (TAT): Time interval from the time of submission of a process to the time of the completion of the process
	Leshob	The average time it takes to complete the process
	Aguirre	Amount of work done by the RPA bot versus a human employee in the same time duration.
	Wanner	The average execution time of an activity
	Kaya	The amount of time it takes to complete the process

Availability		
	Goris	Increased availability of the process by implementing RPA
	Kaya	Amount of extra time the process is active by implementing RPA
	Kroll	Not present
	Wewerka	The amount of time the RPA can work after implementation versus the current availability
	Jimenez-Ramirez	Not present
	Hindel	Increased availability of the process by implementing RPA
Efficiency		
	Santos	Reducing errors, Reducing TAT, Reducing repetitive tasks
	Kroll	Not present
	Hindel	Not present
	Aguirre	Not present
	Wellmann	Not present
	Leshob	Reduce cycle time, reduce error rates
	Kaya	Decreasing mean time to resolution
Reassign employees		
	Santos	Not present
	Siguroardottir	Reduction of FTE required in the process by RPA implementation
	Kaya	Reduction of FTE by RPA implementation
	Wewerka	Reduction of FTE and availability to reassign the employee to more value adding tasks
	Hindel	Reduction of FTE by RPA implementation
	Wellman	Not present
	Devarajan	Reassign to more value adding tasks
	Hofmann	Not present
Customer satisfaction		
	Wanner	Not present
	Lacity	Not present
	Siguroardottir	Fulfill the service better due to RPA reducing errors and improving speed
	Devarajan	Not present
	Hindel	Reduction of FTE and reallocation of employees to customer related tasks
	Kaya	Not present

Transparency		
	Devarajan	Increased process insight with the help of logfiles
	Leshob	Not present
	Anagnoste	Use log files to ensure process transparency
Reporting		
	Devarajan	More data collection to build reports upon
	Kaya	More possibilities to create reporting. Automate reporting with RPA

9.4. Case frequency analysis results

			Top 80% of frequency		Bottom 20% of frequency	
Dataset	Case types	Case frequency	Case types	AVG. Daily Freq.	Case types	AVG. Daily Freq.
1	108	238	2	128	106	20
2	88	238,074	3	511	85	95
3	2059	295,000	200	7784	1859	1974
4	495	988,000	4	2072	491	767
5	655	1,120,000	7	2258	648	509

9.5. Employee satisfaction index – Example questions

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1. I am satisfied with my job when performing this process.					
2. The repetitiveness of the process makes does not lower my satisfaction with my job.					
3. When performing the process, I feel like I add value to my colleagues, the department, and company.					
4. The process is challenging enough to satisfy my needs in a job.					

9.6. Turn around time dataset results

Dataset 1

- Process 1 - $\overline{x}_{TAT_{pc}} = 13$ minutes
- Process 2 - $\overline{x}_{TAT_{pc}} = 8$ minutes
- Process 3 - $\overline{x}_{TAT_{pc}} = 12$ minutes

Dataset 2

- Process 1 - $\overline{x}_{TAT_{pc}} = 1034$ minutes
- Process 2 - $\overline{x}_{TAT_{pc}} = 468$ minutes
- Process 3 - $\overline{x}_{TAT_{pc}} = 1030$ minutes

Dataset 3

- Process 1 - $\overline{x}_{TAT_{pc}} = 1935$ minutes
- Process 2 - $\overline{x}_{TAT_{pc}} = 1619$ minutes
- Process 3 - $\overline{x}_{TAT_{pc}} = 5795$ minutes

Dataset 4

- Process 1 - $\overline{x}_{TAT_{pc}} = 31680$ minutes
- Process 2 - $\overline{x}_{TAT_{pc}} = 33120$ minutes
- Process 3 - $\overline{x}_{TAT_{pc}} = 30240$ minutes

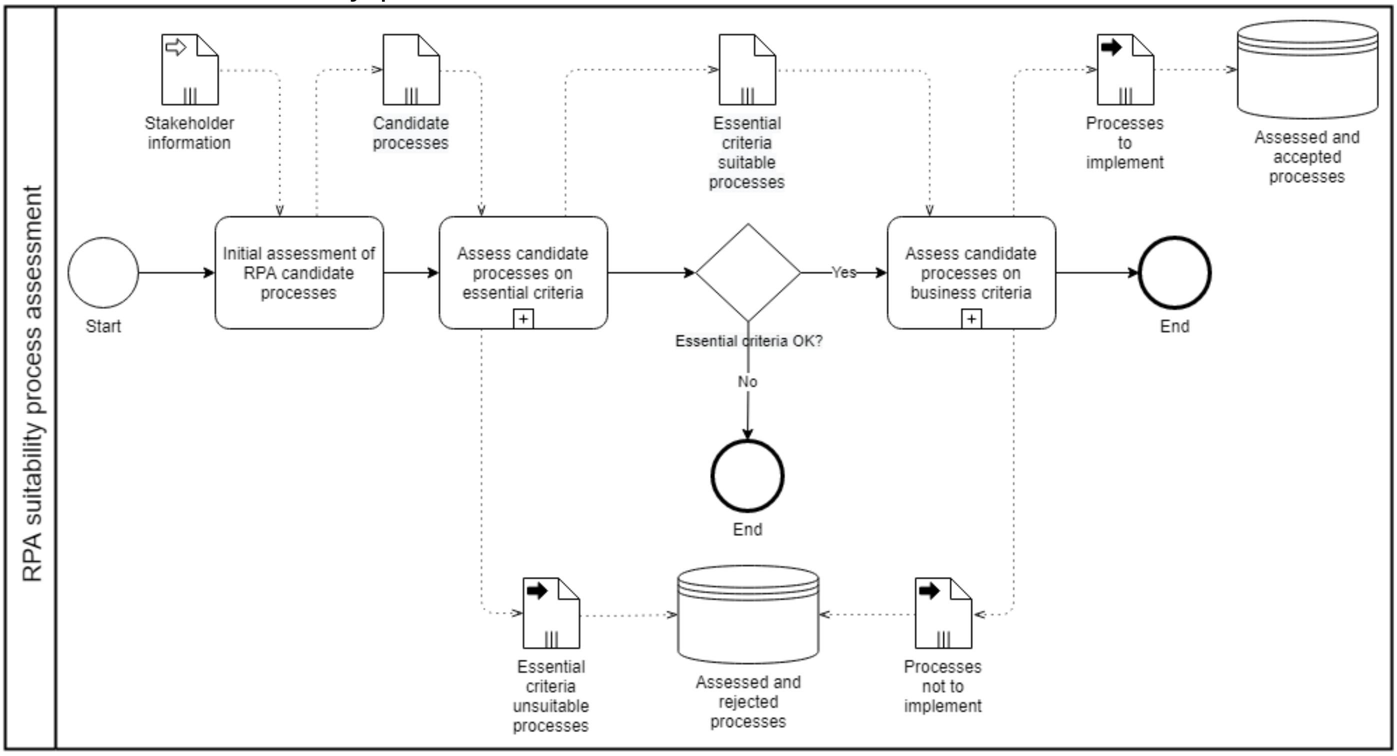
Dataset 5

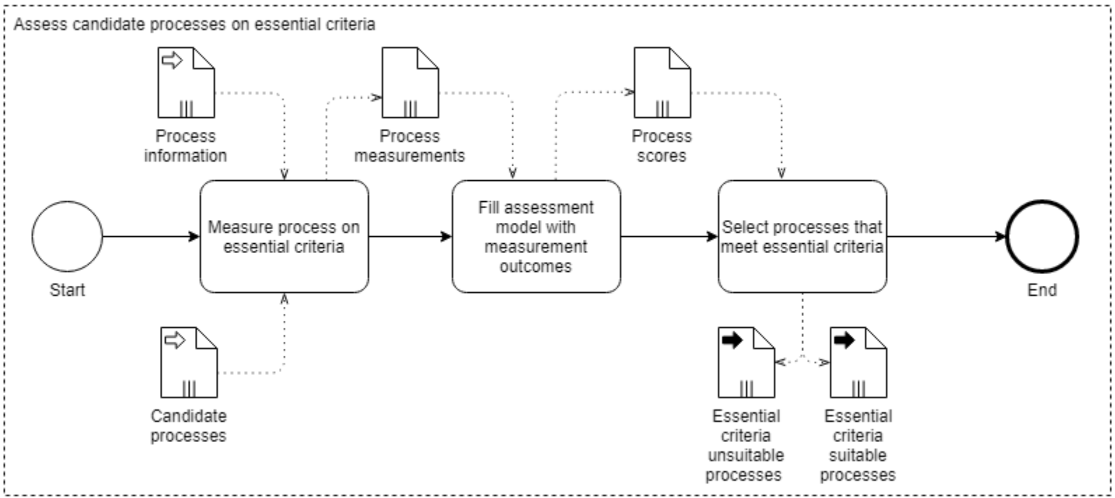
- Process 1 - $\overline{x}_{TAT_{pc}} = 994$ minutes
- Process 2 - $\overline{x}_{TAT_{pc}} = 4117$ minutes
- Process 3 - $\overline{x}_{TAT_{pc}} = 2572$ minutes

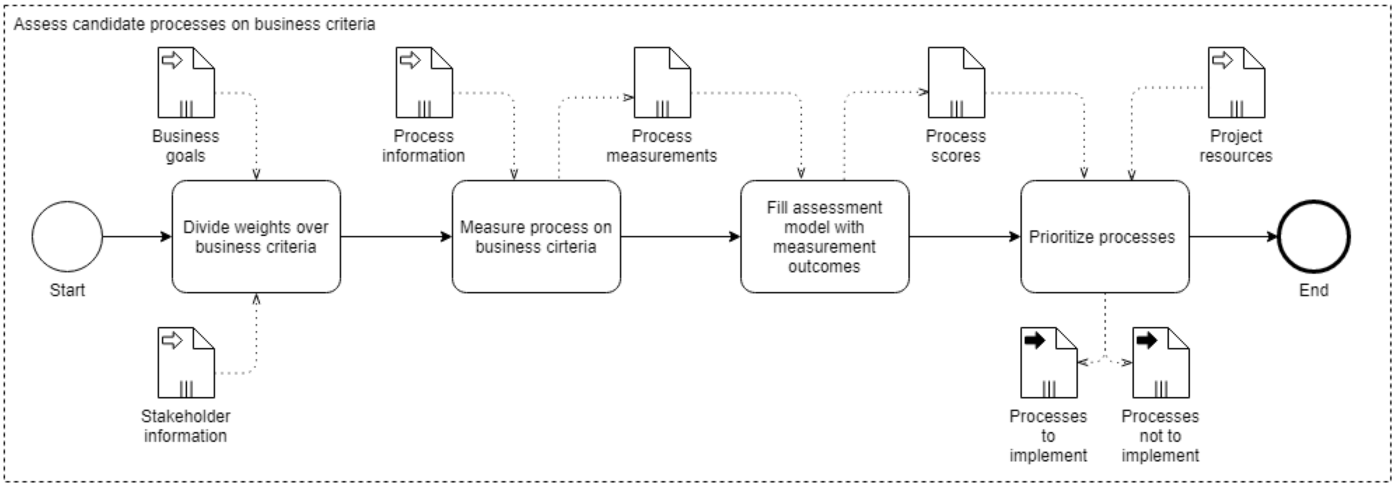
Dataset 6

- Process 1 - $\overline{x}_{TAT_{pc}} = 2879$ minutes
- Process 2 - $\overline{x}_{TAT_{pc}} = 2886$ minutes
- Process 3 - $\overline{x}_{TAT_{pc}} = 11662$ minutes

9.7. RPA suitability process assessment model







9.8. Candidate processes

Process	Name	Description
1	Match invoices	Matching/checking the invoices of the carriers on the actions actually performed
2	Daily transporting report	Create overviews for reports on a daily basis, based on information from the carrier
3	Tube packaging	After the closing of the order intake (8 pm) a different code is assigned to the pipe-product order lines. This action notifies the carriers to pick this on the hub
4	Early delivery requests	These templates are filled in by sales and passed on to the carrier. We get the feedback back and process it
5	Manual registration in the VVA	Manual creation of stop and package data, normally this is generated by the system, but with kitting or leftovers this has to be done manually
6	Find and handle open picking lists	View and look up status and then proceed to the correct status
7	Specials from Non alloc to Alloc	Converting from one location to another location in the ERP for items where this is not done automatically. Often Specials
8	Rejected orders in Astro	Pick orders can be rejected for various reasons and must be processed
9	Printing claims	For the team leaders in the DC, we create claims, scan them, and then email them
10	Free redelivery report	Daily reports for the free redelivery
11	Free redelivery entry	If the decision has been made that a customer can and should receive a free redelivery, this must be entered
12	Hub anomalies	Every day, based on warehouse recordings, we look at what actually happened then specific actions are carried out
13	Purchase orders	Manual correction of unprocessed order messages
14	Connection GVT dashboard	Activities we perform based on the data from the GVT dashboard

9.9. Interview Service Desk manager for RSQ1 – RSQ4

RSQ1 *– Does the artifact assess a process on RPA technology criteria?*

Our selection of RPA candidate processes was created with little knowledge about RPA. We therefor where sure that not all processes would pass the assessment. We hoped that at least a few where applicable for RPA. The first iteration of the assessment model really showed us that a large portion was actually unsuitable for RPA. If we where to skip the assessment part like we used to, or reduce the number of criteria, we would definitely progress with more and thus unsuitable processes for RPA. The model helped us to figure out what processes where suitable and what processes were not.

RSQ2 *– Does the artifact provide the possibility to assess a process on business goals?*

Based on the Service Desk goals, we where able to address those in the assessment model via the weights. We could easily increase the weights on criteria that would help us towards our business goals.

It is difficult to judge if other business goals from other departments would be possible to translate using the model criteria, but I can image that it would be possible. You could even argue that when you are not able to translate the goals wo the weight distribution, you might be looking at a wrong solution to support the completion of your business goal.

Again, for us, the reduction of FTE, increase in efficiency and over all improvement of employee satisfaction was easily translated into the model. We could even see that when we changed the model weight distribution from your template values to our weight distribution values, a process would score way better or sometimes worse.

RSQ3 *– Does the artifact show what process are suitable for RPA?*

Yes. The first iteration makes it clear what processes are suitable for RPA and what processes are not. The second iteration really shows us to what degree the implementation will benefit the Service Desk. By judging the process scores, I am able to select the process that contributes most towards the business goals. Whilst all processes are suitable for RPA, we do not have an unlimited budget to work with. With this overview, I am able to select the processes that contribute most towards are business goals whilst keeping the project budget in mind. All processes had clear over all scores that help us with selecting the best processes to automate using RPA.

Although there is almost no difference in score between process six and seven, I would still be able to decide which process to automate. I would most likely do this by analyzing the individual scores for the criteria that are important to my business goals. I can also imagine deciding based on process priority, some processes are more important for the business continuity then others and thus impact the final decision-making process.

RSQ4 *– Does the artifact supports process mining in a voluntary way?*

Yes, definitely. We could measure all criteria without process mining. Those measurements represent the daily volume, and we could not spot any abnormalities. The measurements might not be spot on, but they are really close to be able to make a good decision for future implementation.

We have seen that process mining did change most of the measurement on process three. However, these changes hardly resulted in any major changes to process scores or individual criteria scores. To me this shows that process mining does improve the assessment but isn’t a must have and is still viable without process mining.

9.10. Results iteration one – essential criteria

Process	Name	Description	Time (*min*)	Score	Failed on	Remark
1	Match invoices	Matching/checking the invoices of the carriers on the actions actually performed	25	3 of 5	Standardization, Rule based	Many exceptions and need of creative thinking
2	Daily transporting report	Create overviews for reports on a daily basis, based on information from the carrier	20	4 of 5	Maturity	Will be adjusted and transferred to a BI solution soon
3	Tube packaging	After the closing of the order intake (8 pm) a different code is assigned to the pipe-product order lines. This action notifies the carriers to pick this on the hub	10	5 of 5	N/A	Eligible for iteration 2
4	Early delivery requests	These templates are filled in by sales and passed on to the carrier. We get the feedback back and process it	10	5 of 5	N/A	Eligible for iteration 2
5	Manual registration in the VVA	Manual creation of stop and package data, normally this is generated by the system, but with kitting or leftovers this has to be done manually	20	4 of 5	Data digitally available	End of the process involves moving a box to the correct shipping dock
6	Find and handle open picking lists	View and look up status and then proceed to the correct status	15	5 of 5	N/A	Eligible for iteration 2
7	Specials from Non alloc to Alloc	Converting from one location to another location in the ERP for items where this is not done automatically. Often Specials	20	5 of 5	N/A	Eligible for iteration 2
8	Rejected orders in Astro	Pick orders can be rejected for various reasons and must be processed	15	4 of 5	Data digitally available	Due to the haste these orders have, the start of the process is often by telephone of 1 on 1 contact
9	Printing claims	For the team leaders in the DC, we create claims, scan them, and then email them	20	4 of 5	Rule based, Data digitally available	Involves manual interpretation of the claims and these claims are not digitally available
10	Free redelivery report	Daily reports for the free redelivery	15	3 of 5	Standardization, Rule based	Ten exceptions present, process is not rule based and requires creative thinking
11	Free redelivery entry	If the decision has been made that a customer can and should receive a free redelivery, this must be entered	15	5 of 5	N/A	Eligible for iteration 2

12	Hub anomalies	Every day, based on warehouse recordings, we look at what actually happened then specific actions are carried out	60	1 of 5	Standardization, Rule based, Data digitally available, Data structure	Sixteen exceptions, Involves creative thinking, Data sources involve: Letters, WhatsApp messages, E-mail, Phone calls, Sticky Notes, etc.
13	Purchase orders	Manual correction of unprocessed order messages	25	4 of 5	Standardization	Eleven exceptions in the process
14	Connection GVT dashboard	Activities we perform based on the data from the GVT dashboard	5	2 of 5	Rule based, Data digitally available, Data structure	Involves research activity based on customer demands often received via telephone without option to digitize the request

9.11. Results iteration two – business criteria

Process	Name	Description	Time (*min*)	Score	Remark
3	Tube packaging	After the closing of the order intake (8 pm) a different code is assigned to the pipe-product order lines. This action notifies the carriers to pick this on the hub	80	2,35	High frequency process in relation to the others.
4	Early delivery requests	These templates are filled in by sales and passed on to the carrier. We get the feedback back and process it	70	2,55	High business priority project.
6	Find and handle open picking lists	View and look up status and then proceed to the correct status	90	2,68	Related to P7.
7	Specials from Non Alloc to Alloc	Converting from one location to another location in the ERP for items where this is not done automatically. Often Specials	120	2,70	Longer time needed to complete the assessment due to lack of documentation.
11	Free redelivery entry	If the decision has been made that a customer can and should receive a free redelivery, this must be entered	60	2,23	Management expected more time spend per week on this process.

9.12. Process 3 – outcome of iteration 2

Criteria	Measurement	Score	Weight	Final Score
Standardization	3	3	*7,00%*	0,210
Data quality		3	*7,00%*	0,210
Consistency (*DCp*)	5			
Documentation	1			
Maturity (*months without change*)	24	5	*2,00%*	0,100
Frequency (*FRpc*)	**151**	1	*2,00%*	0,020
DFRpc 1	*178*			
DFRpc 2	*133*			
DFRpc 3	*121*			
DFRpc 4	*154*			
DFRpc 5	*167*			
Number of involved systems (*NISp*)	1	1	*1,00%*	0,010
Human error	**0**	1	*8,00%*	0,080
Error Rate	**0,00%**			
Human errors day 1	0			
Human errors day 2	0			
Human errors day 3	0			
Human errors day 4	0			
Human errors day 5	0			
Efficiency	100%	1	*10,00%*	0,100
Average error TAT (minutes)	0			
Total process time (minutes)	75			
Return on Investment	**62%**	3	*7,00%*	0,210
Benefits (1 year period)	*€ 6.480,00*			
Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction	10%	5	*10,00%*	0,500
Time saving	**0%**	1	*20,00%*	0,200
Estimated saved time per case (minutes)	**0**			
Average TATpc	***0,5***			
Average TAT day 1	*0,5*			
Average TAT day 2	*0,5*			
Average TAT day 3	*0,5*			
Average TAT day 4	*0,5*			
Average TAT day 5	*0,5*			
Availability	**25%**	1	*5,00%*	0,050
Extra (minutes)	120			
Current (minutes)	480			
Reassign employees	**100%**	5	*10,00%*	0,500
Saved FTE	0,18			
Reassignable FTE	0,18			
Customer satisfaction	2	2	*5,00%*	0,100
Transparency	1	1	*3,00%*	0,030
Reporting	1	1	*3,00%*	0,030
Weights total (*must be 100*)			100,00%	
Total score *Tube Packaging*				2,35

9.13. Process 4 – outcome of iteration 2

Criteria		Measurement	Score	Weight	Final Score
Standardization		3	3	*7,00%*	0,210
Data quality			3	*7,00%*	0,210
	Consistency (*DCp*)	3			
	Documentation	3			
Maturity (*months without change*)		15	4	*2,00%*	0,080
Frequency (*FRpc*)		**30**	1	*2,00%*	0,020
	DFRpc 1	*13*			
	DFRpc 2	*45*			
	DFRpc 3	*35*			
	DFRpc 4	*31*			
	DFRpc 5	*29*			
Number of involved systems (*NISp*)		3	3	*1,00%*	0,030
Human error		**2**	2	*8,00%*	0,160
Error Rate		**6,67%**			
	Human errors day 1	3			
	Human errors day 2	1			
	Human errors day 3	0			
	Human errors day 4	1			
	Human errors day 5	4			
Efficiency		96%	1	*10,00%*	0,100
	Average error TAT (minutes)	4			
	Total process time (minutes)	90			
Return on Investment		**80%**	3	*7,00%*	0,210
	Benefits (1 year period)	*€ 7.200,00*			
	Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction		75%	2	*10,00%*	0,200
Time saving		**33%**	2	*20,00%*	0,400
Estimated saved time per case (minutes)		**1**			
Average TATpc		**3**			
	Average TAT day 1	*4*			
	Average TAT day 2	*2*			
	Average TAT day 3	*3*			
	Average TAT day 4	*3*			
	Average TAT day 5	*5*			
Availability		**0%**	1	*5,00%*	0,050
	Extra (minutes)	0			
	Current (minutes)	480			
Reassign employees		**100%**	5	*10,00%*	0,500
	Saved FTE	0,2			
	Reassignable FTE	0,2			
Customer satisfaction		4	4	*5,00%*	0,200
Transparency		2	2	*3,00%*	0,060
Reporting		4	4	*3,00%*	0,120
Weights total (*must be 100*)				100,00%	
Total score *Early delivery request*					2,55

9.14. Process 6 – outcome of iteration 2

Criteria		Measurement	Score	Weight	Final Score
Standardization		1	5	*7,00%*	0,350
Data quality			5	*7,00%*	0,350
	Consistency (*DCp*)	5			
	Documentation	5			
Maturity (*months without change*)		12	3	*2,00%*	0,060
Frequency (*FRpc*)		**19**	1	*2,00%*	0,020
	DFRpc 1	*16*			
	DFRpc 2	*19*			
	DFRpc 3	*35*			
	DFRpc 4	*16*			
	DFRpc 5	*10*			
Number of involved systems (*NISp*)		2	2	*1,00%*	0,020
Human error		**1**	2	*8,00%*	0,160
Error Rate		**5,21%**			
	Human errors day 1	1			
	Human errors day 2	2			
	Human errors day 3	1			
	Human errors day 4	0			
	Human errors day 5	1			
Efficiency		90%	1	*10,00%*	0,100
	Average error TAT (minutes)	2			
	Total process time (minutes)	20			
Return on Investment		**-55%**	1	*7,00%*	0,070
	Benefits (1 year period)	*€ 1.800,00*			
	Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction		20%	5	*10,00%*	0,500
Time saving		**0%**	1	*20,00%*	0,200
Estimated saved time per case (minutes)		**0**			
Average TATpc		**1**			
	Average TAT day 1	*1*			
	Average TAT day 2	*1*			
	Average TAT day 3	*1*			
	Average TAT day 4	*1*			
	Average TAT day 5	*1*			
Availability		**0%**	1	*5,00%*	0,050
	Extra (minutes)	0			
	Current (minutes)	90			
Reassign employees		**100%**	5	*10,00%*	0,500
	Saved FTE	0,05			
	Reassignable FTE	0,05			
Customer satisfaction		3	3	*5,00%*	0,150
Transparency		3	3	*3,00%*	0,090
Reporting		2	2	*3,00%*	0,060
Weights total (*must be 100*)				100,00%	
Total score *Find and handle open picking lists*					2,68

9.15. Process 7 – outcome of iteration 2

Criteria	Measurement	Score	Weight	Final Score
Standardization	2	4	*7,00%*	0,280
Data quality		3	*7,00%*	0,210
Consistency (*DCp*)	5			
Documentation	1			
Maturity (*months without change*)	24	5	*2,00%*	0,100
Frequency (*FRpc*)	**30**	1	*2,00%*	0,020
DFRpc 1	*28*			
DFRpc 2	*22*			
DFRpc 3	*44*			
DFRpc 4	*32*			
DFRpc 5	*28*			
Number of involved systems (*NISp*)	2	3	*1,00%*	0,030
Human error	**0**	1	*8,00%*	0,080
Error Rate	**0,00%**			
Human errors day 1	0			
Human errors day 2	0			
Human errors day 3	0			
Human errors day 4	0			
Human errors day 5	0			
Efficiency	100%	1	*10,00%*	0,100
Average error TAT (minutes)	0			
Total process time (minutes)	15			
Return on Investment	**-73%**	1	*7,00%*	0,070
Benefits (1 year period)	*€ 1.080,00*			
Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction	10%	5	*10,00%*	0,500
Time saving	**47%**	3	*20,00%*	0,600
Estimated saved time per case (minutes)	**7**			
Average TATpc	**15**			
Average TAT day 1	*14*			
Average TAT day 2	*11*			
Average TAT day 3	*22*			
Average TAT day 4	*16*			
Average TAT day 5	*14*			
Availability	**0%**	1	*5,00%*	0,050
Extra (minutes)	0			
Current (minutes)	480			
Reassign employees	**100%**	5	*10,00%*	0,500
Saved FTE	0,03			
Reassignable FTE	0,03			
Customer satisfaction	2	2	*5,00%*	0,100
Transparency	1	1	*3,00%*	0,030
Reporting	1	1	*3,00%*	0,030
Weights total (*must be 100*)			100,00%	
Total score *Specials from non alloc to alloc*				2,70

9.16. Process 11 – outcome of iteration 2

Criteria		Measurement	Score	Weight	Final Score
Standardization		4	2	*7,00%*	0,140
Data quality			3	*7,00%*	0,210
	Consistency (*DCp*)	5			
	Documentation	1			
Maturity (*months without change*)		15	4	*2,00%*	0,080
Frequency (*FRpc*)		**20**	1	*2,00%*	0,020
	DFRpc 1	*13*			
	DFRpc 2	*21*			
	DFRpc 3	*35*			
	DFRpc 4	*37*			
	DFRpc 5	*58*			
Number of involved systems (*NISp*)		6	5	*1,00%*	0,050
Human error		**0**	1	*8,00%*	0,080
Error Rate		**0,00%**			
	Human errors day 1	0			
	Human errors day 2	0			
	Human errors day 3	0			
	Human errors day 4	0			
	Human errors day 5	0			
Efficiency		100%	1	*10,00%*	0,100
	Average error TAT (minutes)	0			
	Total process time (minutes)	60			
Return on Investment		**17%**	2	*7,00%*	0,140
	Benefits (1 year period)	*€ 4.680,00*			
	Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction		20%	5	*10,00%*	0,500
Time saving		**17%**	1	*20,00%*	0,200
Estimated saved time per case (minutes)		**0,5**			
Average TATpc		**3**			
	Average TAT day 1	*2*			
	Average TAT day 2	*3*			
	Average TAT day 3	*2*			
	Average TAT day 4	*2*			
	Average TAT day 5	*2*			
Availability		**0%**	1	*5,00%*	0,050
	Extra (minutes)	0			
	Current (minutes)	480			
Reassign employees		**100%**	5	*10,00%*	0,500
	Saved FTE	0,13			
	Reassignable FTE	0,13			
Customer satisfaction		2	2	*5,00%*	0,100
Transparency		1	1	*3,00%*	0,030
Reporting		1	1	*3,00%*	0,030
Weights total (*must be 100*)				100,00%	
Total score *Free redelivery request*					2,23

9.17. Process 3 – Process Mining outcome of iteration 2

Criteria	Measurement	Score	Weight	Final Score
Standardization	3	3	*7,00%*	0,210
Data quality		3	*7,00%*	0,210
Consistency (*DCp*)	5			
Documentation	1			
Maturity (*months without change*)	24	5	*2,00%*	0,100
Frequency (*FRpc*)	**152**	1	*2,00%*	0,020
DFRpc 1	*195*			
DFRpc 2	*120*			
DFRpc 3	*125*			
DFRpc 4	*154*			
DFRpc 5	*167*			
Number of involved systems (*NISp*)	1	1	*1,00%*	0,010
Human error	**0**	1	*8,00%*	0,080
Error Rate	**0,00%**			
Human errors day 1	0			
Human errors day 2	0			
Human errors day 3	0			
Human errors day 4	0			
Human errors day 5	0			
Efficiency	100%	1	*10,00%*	0,100
Average error TAT (minutes)	0			
Total process time (minutes)	122			
Return on Investment	**125%**	4	*7,00%*	0,280
Benefits (1 year period)	*€ 9.000,00*			
Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction	10%	5	*10,00%*	0,500
Time saving	**0%**	1	*20,00%*	0,200
Estimated saved time per case (minutes)	***0,00***			
Average TATpc	***0,80***			
Average TAT day 1	*0,80*			
Average TAT day 2	*0,70*			
Average TAT day 3	*0,75*			
Average TAT day 4	*0,75*			
Average TAT day 5	*1,00*			
Availability	**0%**	1	*5,00%*	0,050
Extra (minutes)	0			
Current (minutes)	660			
Reassign employees	**100%**	5	*10,00%*	0,500
Saved FTE	0,25			
Reassignable FTE	0,25			
Customer satisfaction	2	2	*5,00%*	0,100
Transparency	1	1	*3,00%*	0,030
Reporting	1	1	*3,00%*	0,030
Weights total (*must be 100*)			100,00%	
Total score *Tube Packaging*				2,42

9.18. Assessment model overview Frist iteration

Process	Criteria	Score
1	Standardization (N*o more than 5 exception flows?*)	Yes
	Rule based (*Is the process based on business rules?*)	No
	Digitally available (*Is the data digital?*)	No
	Data structure (*Does the structure match the RPA supported structure?*)	No
	Maturity (*At least 3 months without planned changes?*)	Yes

The first iteration of the assessment model consists of five main questions regarding the essential criteria. The goal of this first iteration is to assess if a process is suited for RPA implementation. The stakeholders can assess if a process is applicable by answering these five questions.

In order for a process to be suitable and continue to the second iteration, all five essential criteria questions need to be answered with "yes". If one or multiple questions are answered with "no", the process is deemed unsuitable.

In order to answer these essential criteria questions, the assessor need to understand the process. Together with the stakeholders, available knowledge and documentation, the assessor needs to find enough information to complete the first iteration. Businesses that have access to process mining can also use data in order to get the needed information about the process.

9.19. Assessment mode overview – second iteration

Criteria		Measurement	Score	Weight	Final Score
Standardization		3	3	*6,67%*	0,200
Data quality			3	*6,67%*	0,200
	Consistency (*DCp*)	5			
	Documentation	1			
Maturity (*months without change*)		24	5	*6,67%*	0,334
Frequency (*FRpc*)		**151**	1	*6,67%*	0,067
	DFRpc 1	*178*			
	DFRpc 2	*133*			
	DFRpc 3	*121*			
	DFRpc 4	*154*			
	DFRpc 5	*167*			
Number of involved systems (*NISp*)		1	1	*6,67%*	0,067
Human error		**0**	1	*6,66%*	0,067
Error Rate		**0,00%**			
	Human errors day 1	0			
	Human errors day 2	0			
	Human errors day 3	0			
	Human errors day 4	0			
	Human errors day 5	0			
Efficiency		100%	1	*6,67%*	0,067
	Average error TAT (minutes)	0			
	Total process time (minutes)	75			
Return on Investment		**62%**	3	*6,67%*	0,200
	Benefits (1 year period)	*€ 6.480,00*			
	Cost (1 year period)	*€ 4.000,00*			
Employee satisfaction		0%	5	*6,66%*	0,333
Time saving (*minutes*)		**0%**	1	*6,67%*	0,067
Estimated saved time per case (minutes)		**0**			
Average TATpc		**0,5**			
	Average TAT day 1	*0,5*			
	Average TAT day 2	*0,5*			
	Average TAT day 3	*0,5*			
	Average TAT day 4	*0,5*			
	Average TAT day 5	*0,5*			
Availability		**25%**	1	*6,66%*	0,067
	Extra (minutes)	120			
	Current (minutes)	480			
Reassign employees		**100%**	5	*6,67%*	0,334
	Saved FTE	0,18			
	Reassignable FTE	0,18			
Customer satisfaction		2	2	*6,66%*	0,133
Transparency		1	1	*6,66%*	0,067
Reporting		1	1	*6,67%*	0,067
Weights total (*must be 100*)				100,00%	
Total score *PROCESS NAME*					2,27

The assessment model for the second iteration is a lot more extensive than the assessment model from the first iteration. This is because the second iteration assesses a process on a lot more criteria than the first iteration does and also needs room to track these measurement outcomes. Unlike with the first iteration, the second iteration only consists of data entries, there are no textual answers required for the second iteration model. All measurements, as described in chapter 4, are present in the model and can be documented in the model.

Criteria
The first column of the assessment model consists of the criteria. These are all business criteria, there are no essential criteria present in the second iteration. The first column consists of all mentioned business criteria from chapter 3 and 4. Some criteria consist of multiple components that need to be measured in order to complete the criteria measurement. The Return on Investment criteria for example consist of a separate cost and benefit measurement input option which will be used to automatically calculate the ROI measurement. Criteria Time Saving and Human Error have five separated input sections for their required five-day measuring period in order to create the average over a one business week period.

Measurement
The measurement column is the column that the assessor will adjust according to the process assessment. In this column, all measurement outcomes need to be documented. During the process assessment the stakeholders measure the businesses criteria according to their respective measurements. The assessment model accommodates all measurements, and the assessor can therefore document these in the model. For some criteria, this means that a score between one and five needs to be filled in, and for others this means the outcome conducted measurements need to be insert.

Score
This column of the assessment model is automatically filled by the assessment model based on the measurement input and represents the scoring scales from chapter four. Here, the assessment model translates the filled in measurements to the criteria scoring scale and automatically determines the criteria score based on this measurement. The assessor does not need to adjust anything in this column since it is completely automized.

Weight
The weights need to be adjusted according to the business goals of RPA implementation. The stakeholders increase the weights of criteria which will contribute towards the business goal and decrease the weights on criteria that do not. It is up to the stakeholders how these weights are distributed. The model does require that the total of all weights is equal to 100%. If this is not the case, the assessment is unreliable and will not provide the right conclusion. The assessor is informed by the assessment model when the total weights are not equal to 100% via a red weight field.

Final score
The model has two types of final score, one final score per criteria and one final process score. Both the criteria final score and process final score are automatically calculated by the model. By multiplying the criteria score with the weights, a final criteria score is created. The accumulation of all criteria final scores represents the process final score. This final process score is always between one and five. Here, the stakeholders can see the process contribution towards the business goals, where processes that score closer to a five contribute more towards the business goals than processes that score closer to a one.

Every process will have its own assessment model table as shown on page 131. The model does not support multiple processes in one assessment table. By adjusting the measurements and weights of the model, the assessor is able to complete the second iteration of the assessment model and see, based on the final process score, to what extend a process contributes towards the company's business goal.