Evaluating and Developing Methods to Assess Business Process Suitability for Robotic Process Automation

A Design Research Approach

Master's Thesis in Software Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
AND UNIVERSITY OF GOTHENBURG
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Abstract

Robotic Process Automation (RPA) is an emerging approach to automation within or across information systems. While it has grown immensely during recent years, academic studies on the topic have been quite scarce. This study focuses on one aspect of this automation, namely how to select which processes to automate. The purpose of this study is to review existing methods for selecting processes to automate and if possible, suggest improvements to these. In addition, this study also aims to investigate if BPMN (Business Process Model and Notation) can be used to assist in the process selection.

In order to fulfill this purpose, the study began by reviewing existing methods and gathered a total of 23 methods or recommendations for how to select processes. These methods were then applied at a partner company for four specific processes. The processes were selected during a set of interviews after which the processes were modelled using BPMN and assessed using the criteria from the existing methods.

This revealed a number of issues with existing methods and the use of BPMN for this purpose. A new methodology was designed, the RPA Suitability Framework, which tried to address these issues, both with the existing selection methods as well as BPMN.

The RPA Suitability Framework was then applied to five new processes from the partner company to see how it fared compared to previous methods. This evaluation was done by comparing the outcome of the methods, the content of the methods as well as during an evaluation workshop with the partner company. Many improvements could be seen, but further testing of the new framework would be needed before a general recommendation to use it could be given.

Keywords: Robotic Process Automation, assessing process suitability, criteria evaluation, modelling, BPMN 2.0

Acknowledgements

Before we get into this thesis there are a number of people we would like to thank, without whom it would not be possible to complete this project. First of we would like to thank our supervisor Jennifer Horkoff for all the support and feedback that you gave us as well as the patience you showed while we struggled to grasp different concepts throughout the process. We would also like to thank our sponsor at the partner company, Rickard, who initiated this project. Thank you for introducing us to RPA and allowing us to test both existing and our new method for selecting processes within your organization. Finally we would like to thank our examiner Robert Feldt for keen insights and feedback that helped develop and deepen our work.

Björn Agaton and Gustav Swedberg, June 2018

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1
Introduction

There is a discussion about the general future of the job market, faced increasing automation across different professions. A study by Frey and Osborne [1] investigates over 700 different occupations, estimating the likelihood of them being computerized and came to the conclusion that the bulk of office and administrative support jobs are at risk. This general move towards automation that can be seen across business areas, expands beyond the physical spectrum to software implementations.

An emerging approach to automation within and across enterprise information systems is called Robotic Process Automation, RPA [2]. Despite what the term robotic might imply, RPA is a software based technology designed to automate processes by mimicking human behavior [3]. The software robot, which is how RPA is often described, uses the same graphical user interface of the target system as that of a regular user and is often run in a virtual environment [4]. This sets RPA apart from more traditional business process management (BPM) tools, which may automate via interaction with back-end and data layers [5]. Asatiani and Penttinen [3] argues that while redesigned systems with built-in automation might be superior, RPA technologies present a temporary solution that excels in flexibility and speed in the implementation phase.

While RPA has a lot to offer, it has its challenges as well. An obvious challenge is to find a business case that can utilize the value of RPA. Finding a good business case includes finding the right processes to automate, but to determine if processes or sub-processes can or should be automated is not always self-evident. Is there a generally superior solution or is it dependent on the processes and are there processes where automation is currently not an option? That question will be the starting point of this study.

Methods and criteria to evaluate process suitability for RPA have been produced both from academia and the industry. However, the academic methods that exist (e.g. [2], [3]) are not very specific and lack practical guidelines to follow. Besides, nearly all publications come from the same authors which shows that this subject needs further investigation from academia. There are far more methods and criteria from the industry, e.g. [6]–[9], but these have not been extensively evaluated and there are also many differences between the ones that exist.

An important step in any process automation is to map the processes to be automated as it allows the process to be analyzed [10]. Business process modeling is widely used for this and the standard notation Business Process Model and Notation, BPMN [11], is often used. While BPMN has seen widespread use and is by some considered to be a key part of RPA implementations [12], there is a lack of discussion about its suitability and limitations in academia in regards to assessing the suitability of RPA for a particular process. It is still uncertain as to what extent BPMN can be used for assessing process suitability for RPA.

This study was done in collaboration with a partner company, which is anonymous. It is a large global company that produces equipment for many industries, including manufacturing, construction, automotive, mining, oil and gas. One of the divisions in the partner company is looking into acquiring RPA solutions to automate various processes. Some processes in another division, primarily financial processes, have already been automated as test cases for RPA but they need help investigating for what other processes this technology might be applicable.

1.1 Purpose of the Study

The purpose of the study is to:

1. Test if modeling business processes using BPMN can help assess process suitability for RPA.
2. Test existing methods, such as recommendations, guidelines and criteria from academia and industry, for assessing process suitability for RPA.
3. Develop a new methodology which solves potential issues with the methods applied above.
4. Provide the partner company with a methodology for assessing process suitability for RPA.

This type of methodology could further be used by other companies that are looking into acquiring RPA or researchers that can use it as base for continuing research in the RPA field.

1.1.1 Research Questions

A set of research questions has been created in order to formalize what is needed to research in order to fulfill the purposes of this study. The research questions are as follows:

RQ1: How suitable are existing tools and methods, e.g. business process modeling using BPMN [11] and decision criteria recommended by academia and industry (e.g. [2], [3], [6], [7]), for evaluating the suitability of business processes, or potential sub-processes, for automation via RPA? Specifically the following aspects will be considered:

RQ1.1: Are there important aspects that BPMN fail to cover when it comes to evaluating process suitability for RPA? Does BPMN include aspects that are not needed?

RQ1.2: If recommendations and guidelines from academic and industry sources fail to capture important criteria for evaluating process suitability for RPA, what criteria are missed? Do they include criteria that are not important?

RQ2: Given experiences from RQ1, how can existing tools and methods be improved and expanded to better evaluate the suitability of business processes (and subprocesses) for automation via RPA? Are there aspects in existing tools and methods that indicates that a new method would prove more beneficial?

1.2 Thesis Outline

Chapter 2 presents relevant concepts, technologies and methods necessary to gain sufficient background knowledge for this study. It contains sections about process automation in general and how RPA relates to that field. It also contains an introduction to BPMN as well as research related to this study. The related research includes both sources from academia as well as industry recommendations regarding how to select suitable processes for RPA.

Chapter 3 describes the methods used in this study. This study follows the design research methodology which is divided into three phases: the problem identification phase, the design phase and the evaluation phase. However, since the phases were iterated several times, the chapter is structured after how activities were carried out in chronological order. During the problem identification phase, existing methods of selecting suitable processes, described in Chapter 2, were used at the company. The issues that were identified was then addressed during the design phase by developing a new methodology building upon existing ones. Finally during the evaluation phase the new methodology was used at the partner company and its performance was evaluated.

Chapter 4 contains the results of the study. The results are divided by the three phases described in Chapter 3. The shortcomings of existing methods are presented in the problem identification phase, the new methodology in the design phase and the results of the evaluation in the evaluation phase.

Chapter 5 contains a discussion about the results from Chapter 4 as well as general conclusions drawn from the study. The research questions from Section 1.1.1 will be answered in this chapter.

2
Background

This chapter presents concepts, technologies and methods that frame the research presented in this study and helps the reader with understanding the topics discussed. It begins with a section regarding process automation, an introduction to what RPA is and what it is not and how RPA is related to other automation technologies. After that follows an introduction to BPMN and how it is related with the research topic. Finally the chapter contains a section with previous work related to the topic of selecting suitable processes for RPA. It covers both academic studies about selecting processes for RPA as well as industry recommendations.

2.1 Process Automation and RPA

Process automation is nowadays a common phenomenon which can be seen across various labour markets. Process automation has evolved from using machines to perform physical tasks to later include computers to also perform service tasks [13]. A requirement for process automation has always been that the process is repetitive[13] but while automation is spreading further to new business areas, not everything that is repetitive seems to be easy to automate. Additional process characteristics have also shown to be important. Frey and Osbourne [1] explains how "computerization" can often be seen in routine intensive occupations with well-defined procedures. Tasks that require a high cognitive level are still mostly being performed by humans [1]. The common criteria to investigate when automating processes are consequently routine or non-routine and manual or cognitive.

RPA is the automation technology in focus in this study. While it has become an industry buzzword lately [14] it has not received much academic attention compared to process automation in general which is a mature research subject. The technologies that RPA builds upon have also been around for many years. Screen scraping for instance has been used commercially for more than 20 years [15]. However, use of these technologies in the context of RPA has only existed for a few years [16].

While the term RPA is readily adopted by many service providers (e.g. Blue Prism[17] and Automation Anywhere[18]), the technology is under constant development and it gains improved capabilities rapidly[2]. Because of this constant change, it is important to define which type of RPA that is targeted in this study. Willcocks, Lacity and Craig[4] defines desktop RPA as a set of tools that build upon known technologies (such as macros, scripting and screen-scraping) and the usage of them together in an automation tool. In another article, Lacity and Willcocks[2] makes the distinction between rule-based RPA and cognitive automation, where the latter is based on inference. The more advanced cognitive automation solutions that are up and coming involve natural language processing, which can handle unstructured data from sources such as emails. With more advanced data analysis, the robots learn to understand what the data means and can take decisions based on it, which is too complex for the rules-based RPA described earlier[2]. For the purposes of this study, RPA will be viewed as the rules-based automation and not cognitive automation. One can ask what will happen to this distinction when more cognitive capabilities are bundled together with existing RPA solutions, which analysts at Deloitte suggest is happening[19]. This is discussed in Section 5.4 but not as a part of the formal research.

Since RPA technology uses the same interface as a human user, there is no need to modify or replace the existing system. To achieve the same automation by changing the original system would be a more complex and expensive task, while RPA solutions allow more business processes to be automated using the same resources [5]. Furthermore, modifying processes within proprietary systems are often not possible without enlisting outside help.

So why do companies use RPA? There are many perspectives on that and different sources highlight different aspects. The most commonly occurring theme or reason for using RPA is cost savings, stated by multiple sources [3], [9], [19]–[29]. Others specifically highlight that costs reduction is not the only purpose of RPA [2], [5], [28]. These other strategies can be regulation compliance [22], [24], [25], [29], [30], process speed and efficiency [19], [23]–[26], quality assurance and error reduction [9], [23], [25], [26], [30], upskilling the workforce by removing mundane tasks [9], [23], [30], flexibility or scalability [25] or it can be seen as a strategic move to stay relevant in a changing technological landscape [2], [5], [26], [29].

2.2 Business Process Model and Notation (BPMN)

The research focus in this study is set on methods for assessing business process suitability for RPA. In order to assess the suitability of a process, it is important to first describe and define the process. One of the most widely used notations for visually describing business processes is BPMN, which is why it has been included in this study.

BPMN is a notation for modeling business processes that is maintained by the Object Management Group [11]. BPMN has evolved much from its original state, both in how it looks and its usage. The version that is used in this study is BPMN 2.0 [11]. It has been used across various industries to capture business processes [31]. While the main usage of the notation is describing the processes, it can be also used together with other languages and tools for simulation and even process execution [31]. In this study, BPMN will be used to model processes and evaluate whether the model is sufficient to determine process suitability for RPA, which has not been studied. Some of the common elements of BPMN are shown in Figure 2.1 and an example model is included in Figure 2.2.

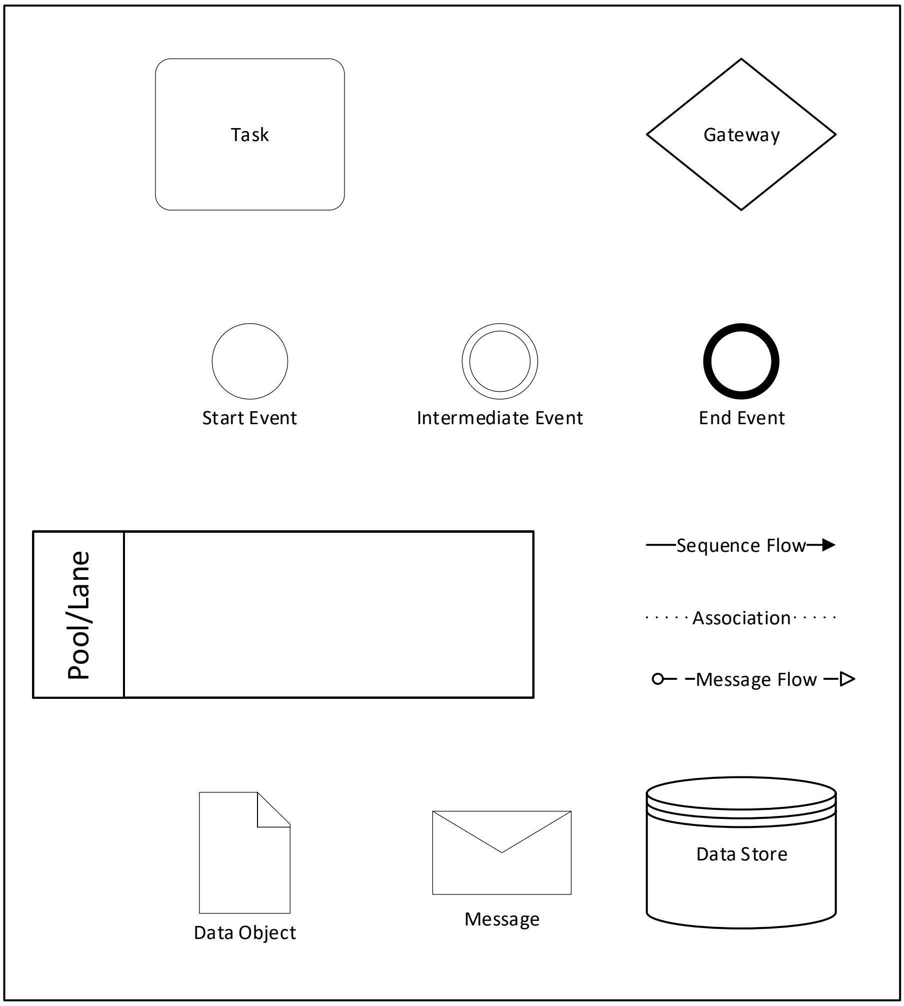

Figure 2.1: Some of the common elements of BPMN.

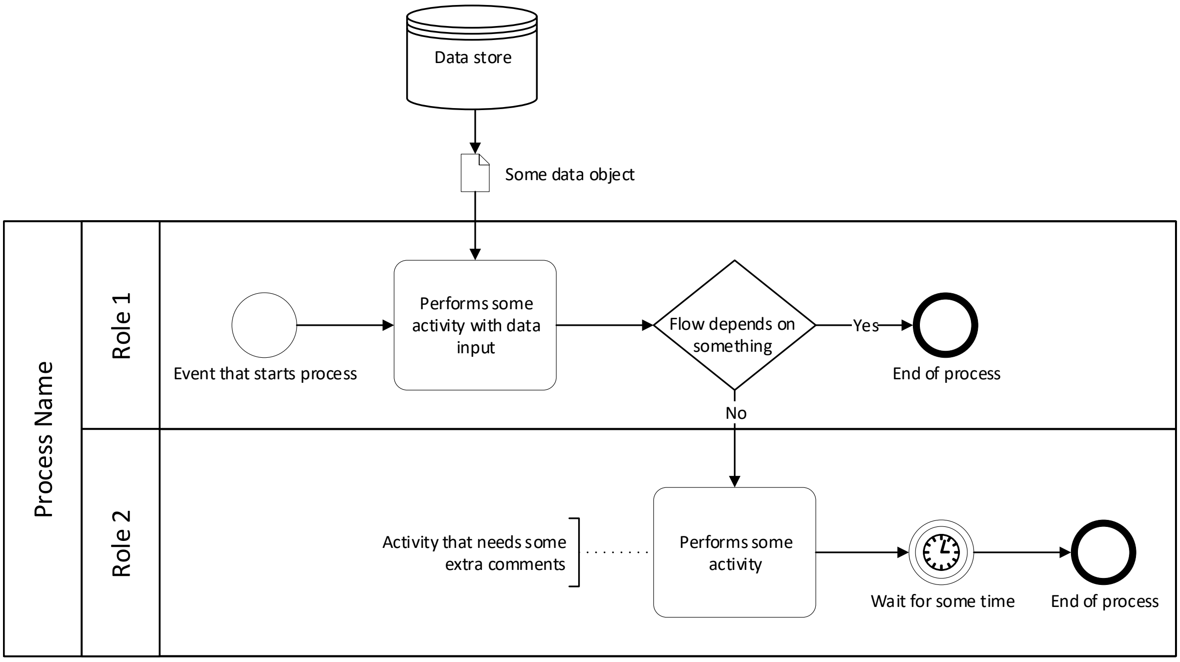

Figure 2.2: Example model of a process in BPMN.

2.3 Related Work

The adoption of RPA is still in an early stage and only in recent years have companies started using it commercially. During this time RPA usage areas has been widely discussed by various technological analyst firms, consulting companies and industry magazines e.g. [6], [7], [32] but only limited academic research exists to back it up [2]–[5], [33]. This chapter takes a look at the work that has been done by both industry and academic sources.

2.3.1 Processes Suitable for RPA (Academia)

In the few academic studies on process suitability for RPA that exists, researchers use different methods to decide if a process is applicable for RPA or not, e.g. Lacity and Willcocks [2] and Asatiani and Penttinen [3]. Asatiani and Penttinen [3] uses a model adopted from Frey and Osbourne [1], which is based on two criteria to evaluate processes: how routine a process is considered and the level of cognitive reasoning that is needed. According to this model, routine processes with little or no cognitive reasoning are most suitable for RPA [3]. This model is supplemented by a number of criteria which, together with routine and low cognitive requirements, is included below.

The full list of criteria from Asatiani and Penttinen:[3]

1. Routine

2. Low cognitive requirements
3. Definable
4. High transaction volume
5. Multiple systems
6. Stable underlying systems
7. Rules based
8. Error prone
9. Few exceptions
10. Clear costs

Willcocks et al. [5] do not present a clear list of criteria but rather discuss characteristics that are important. The discussion includes some similarities but also differs from the list presented by Asatiani and Penttinen[3]. The characteristics that Willcocks et al.[5] discuss can be seen below:

1. Clear business value
2. Clear costs
3. Stable
4. High transaction volume
5. Multiple systems
6. Rules based
7. Standardized

2.3.2 Processes Suitable for RPA (Industry)

Far more recommendations are available from industry sources, both in the form of criteria checklists or in discussions that cover criteria or preferred characteristics. Accenture [7] for example, propose a checklist with five criteria for assessing RPA suitability which is presented below.

1. Rule based process, not dependent on human judgment
2. Initiated by digital trigger and reliant on digital data
3. Process should be functioning and stable
4. Bigger volume of executions of the process is better
5. Process should leverage key it system to provide proof of concept

Other sources share similar lists but with some differences. For example, Deloitte [6] add that processes involving multiple applications are good targets for RPA implementations. Another division within Deloitte [32] describes processes suitable for RPA as:

1. Repetitive
2. Prone to error
3. Rule based
4. Involves digital data

5. Time critical and seasonal

The full list of criteria per source can be found in Appendix D. What is clear is that while methods from industry sources have criteria in common, there are also many differences between them. Even though these methods might have been tested in practice, there are no studies that cover this. Since they have not been investigated in academic studies, there is a need to evaluate them.

3
Methods

This chapter aims to describe and justify the way the study was carried out. To answer the research questions set in Chapter 1, this study will follow the Design Science methodology [34], [35]. Hevner et al. describes Design Science as a problem solving process in information systems research. The methodology aims to create and evaluate an artifact intended to solve some identified problem [35].

This study was carried out in three phases that build on the framework for carrying out information system research, also presented by Hevner et al. [35]: The problem identification phase, the design phase and the evaluation phase. The problem identification phase is a combination of mapping the environment of the research subject and utilizing the existing knowledge base which are two elements in Hevner et al.'s framework. The two subsequent phases are directly taken from the same framework.

Since this study follows the design science phases, it would perhaps be natural to structure this chapter according to those three different phases. However, there is a lot of overlap in between the phases or iterations within or between phases. In order to clearer describe what was done in this study this chapter has been laid out with sections covering the different activities that have been done in a more chronological order. Overall the process went from understanding the problem, to designing the new method and lastly evaluating the new method. In practice this meant moving between design and evaluation throughout a series of smaller iterations after the problem had been understood.

3.1 Understanding the Problem

The initial problem description came from the partner company, which had started an RPA project in one division and wanted to continue it in another division. They had an idea of which processes to choose but were not certain. In order to further understand their problem and how existing process selection methods could or could not help, initial meetings with the project leader for the RPA project were held. These meetings revealed that initial efforts had selected, using a method from the consultancy company involved, a number of processes to be automated. After the implementation started, some of these processes proved harder to implement which might point to issues with that selection method.

During an initial literature review, a large number of methods for selecting processes were found. These methods were often different from each other or sometimes not specific in how they were to be used. To assist the partner company, these methods had to be tested to see if they worked. If there were issues with these, the Design Science methodology could be used to solve the problem of identifying and assessing process suitability for RPA by designing a new methodology. The creation of a methodology for this would serve as the Design Science artifact that would later be evaluated.

3.2 Finding Existing Methods

With an understanding of the problems the company was facing, the first task was to search for existing work within the research subject: How to identify and assess process suitability for RPA, and consequently, if this work included specific methods to do this identification and assessment. The amount of academic work about the subject was at the time of writing limited and only seven relevant academic articles were found. Articles that were considered relevant either had specific guidelines on how to identify and assess processes for RPA, or had some kind of discussion about the topic. The relevant articles found were all covered in this study.

The subject was however widely written about by the industry, which contributed with a larger subset of this study's existing work review. The relevance of the material from industry sources was assessed in the same way as for academic sources. It was not possible to cover all industry sources due to time limitations of the study. For this study, a sample selection of 23 sources could be covered. The sample was based on a report by HfS [36] which names the companies that are leaders in the RPA field. HfS is an analyst firm within automation, artificial intelligence, blockchain, internet of things, digital business models and smart analytics. The article compares companies by several factors that focus on implementations of RPA, which is strongly connected to the research subject. Three additional sources were also added to complement the other sources and although they were all large consultancy firms with experience of RPA they were not mentioned in the list from HfS [36].

All sources that were chosen discussed process selection for RPA in some way or had specific methods for this. Criteria and guidelines, included in these articles were extracted and put into a list of a total of 118 criteria which can be found in Appendix A.

The researchers could not find any previous work related to the usage of BPMN for RPA purposes. When learning how to use BPMN, the guides provided by the Object Management Group[37] were mainly used but also some online tutorials e.g. from Visual Paradigm[38].

3.3 Consolidating Criteria from Existing Methods

The existing methods have different ways of expressing which process characteristics are important in order to automate with RPA. Some methods have an explicit list of criteria e.g. [6]–[8], others have longer descriptions e.g. [3], [20]. In order to analyze the methods, a consolidation of the criteria had to be made, where longer descriptions were interpreted and summarized. Consolidating the longer descriptions enabled these methods to be compared with the others. It also simplified validation of the list when discussing criteria with interviewees, as a smaller number of criteria with less overlap had to be reviewed and discussed. The consolidation also removed redundancies when sources share the same opinion but use different wording. The consolidation was done qualitatively by the researchers. First individually, to assure that the information was interpreted the same way. Then the individual result was merged together. If the researchers had a different summary of the criteria from a source, that source was reviewed closely and discussed until consensus could be reached. The list of 118 criteria, Appendix A, could, by consolidation be shortened down to a list of 49 criteria, which is found in Appendix B. In the consolidated list, each criterion was deemed unique in some way even though several might appear similar.

3.4 Applying Existing Methods

After consolidating the criteria from existing methods the next step was to evaluate them to identify potential problems with the methods. This was done by applying the methods to actual processes at the partner company, to see what could be learned, as well as analyzing the methods on their own which will be covered in Section 3.5. In this study, applying the methods actually refers to applying the criteria of the methods since no further instructions on how to use the methods have been provided. This is likely close to their intended use but will be discussed in Section 5.5.

In order to apply the methods, the first step was to select processes which the methods would be applied to. This was done by carrying out thirteen interviews on site at the partner company. The interviewees that were chosen were either heads of departments or process experts. The interviews with heads of departments had the goal of identifying RPA opportunities within that department and the interviews with process experts had the goal of collecting enough information about a process so it could later be modeled and analyzed. When needed, the process expert also provided a demonstration of the process so the researchers could observe how to perform it. The two types of interviews were both performed in a semi-structured way since this allows the researcher to change the interview direction in an explorative manner when it seems beneficial while still making sure to include all questions in the interview guide[39]. The interview guide that was used during the interviews can be found in Appendix G.

Ten of the interviews were recorded and the reason for the other three not being recorded varied. In one case there were technical issues causing the recording to not start and in another case the interviewee requested the interview not to be recorded. Finally one interview was not recorded as the time allocated had to be cut and it was therefore impossible to cover the intended process. Instead another interview was planned for the second round of interviews, covered in Section 3.7. As the main goal of the interviews was to gather enough data about at least one process to be able to model the process and assess it using the criteria, the use of the material from the interviews was for these two things. In total, four processes were selected to be used to test existing methods. The selection was based on how well the processes were described and understood so that they could thoroughly be assessed.

After enough information about a process had been gathered the process was then modelled using BPMN. To create the models, Microsoft Visio was used along with the included BPMN template which follows the BPMN 2.0 standard[11]. While modelling, the interviews were constantly consulted, both the notes and the recording in order to model the process in the way it had been described and shown.

When the model was complete the 49 consolidated criteria, discussed in Section 3.3 and found in Appendix B, were then used to assess the process by checking which criteria were fulfilled by the process. The notes and recordings of the interviews were vital to this assessment as many of the criteria were directly asked about during the interview, as can be seen in the interview guide found in Appendix G. For some other criteria, regarding aspects such as complexity, the interviewee was not directly asked about this. Rather it was assessed by the researchers based on the overall impression of the process. The assessment of the criteria was carried out individually by each researcher and compared when complete. Any differences were discussed until a consensus was formed.

All the process expert interviewees participated in a validation meeting afterwards to assure that the mapping, analysis and evaluation of each process had been done correctly. This was done by first showing the BPMN model and walking through it with the interviewee. This was done to show how the process was understood and check if it had been captured correctly. Then the assessment of the process was shown and walked through by first describing the criteria and then how the process was perceived to fit that criteria. If the process expert did not agree with the assessment, it was changed accordingly.

3.5 Analyzing Existing Methods

The analysis of existing methods was done in a few different ways. The analysis already started when attempting to understand and consolidate the criteria which was covered in Section 3.3. This was followed by a qualitative analysis of how easy the criteria were to understand. Once the criteria of the methods had been used in practice, which was covered in Section 3.4, the criteria were also analyzed based on their easy of use as well as their significance, that is if they actually assisted in assessing the RPA suitability of a process. Initially, these three points were quantified by receiving a score between 1 to 5 where 5 was describing a criteria that was easy to understand, easy to use and played a significant part in the assessment respectively. This assessment was done individually by the researchers and then merged together. Any notable differences were thoroughly discussed until consensus could be formed. The results of this assessment can be found in Appendix F. Note that this was an initial assessment and the criteria evaluation was subject for iteration. It proved helpful for the final qualitative evaluation, of which the results are described in Section 4.2.

This analysis was also complemented with an attempt to categorize existing methods using an affinity diagram, included below in Figure 3.1. This was done to reveal if and how different criteria were grouped and if so, relevant categories were to be created to describe groups of criteria. In Figure 3.1, the orange notes are potential categories, such as *Business Value*, while the green notes are the 49 consolidated criteria.

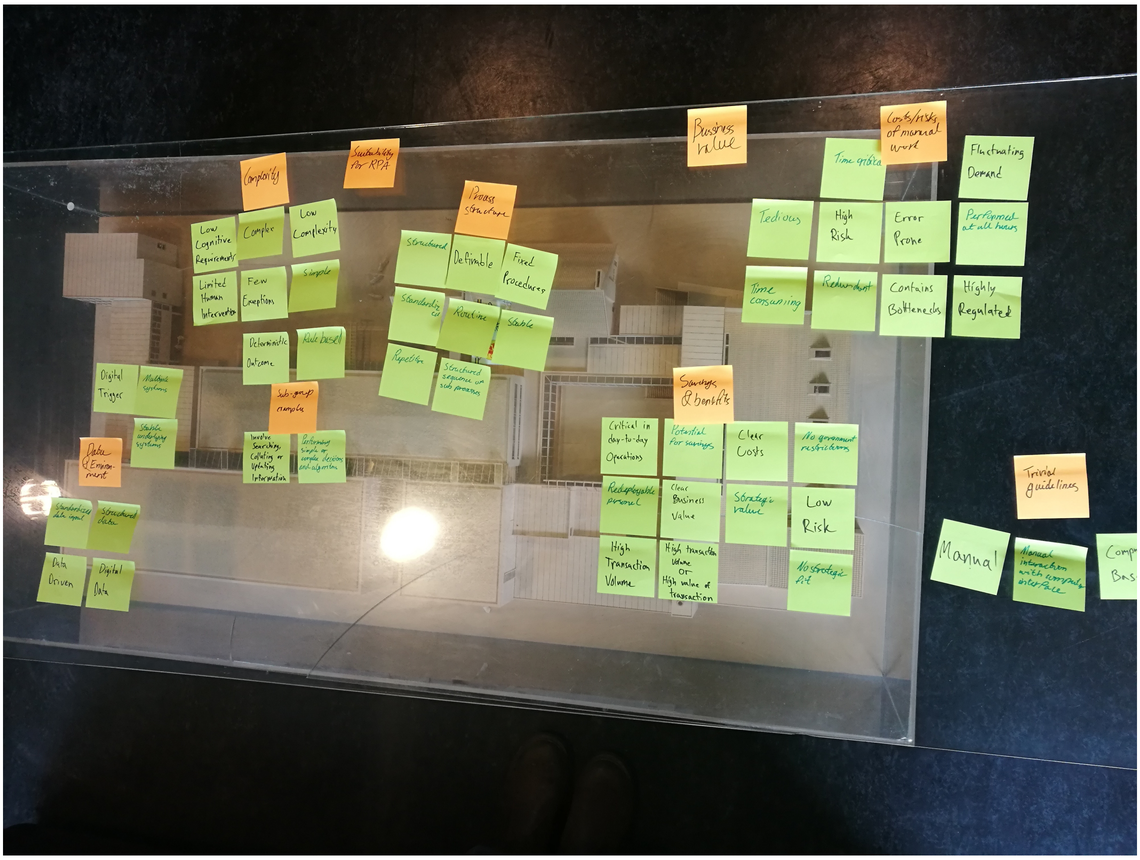

Figure 3.1: Affinity diagram with some potential categories of criteria.

When analyzing the results from the application of existing methods, the results were imported to QlikView in order to compare the results from different methods with each other. QlikView is a platform for enabling analysis of data by calculating and visualizing it in various ways. The calculations made in Qlikview are the basis for the results presented in Section 4.4.3. A screen shot from Qlikview can be seen in Figure 3.2. The screen shot shows the percentage of each methods criteria that are fullfilled for a specific process.

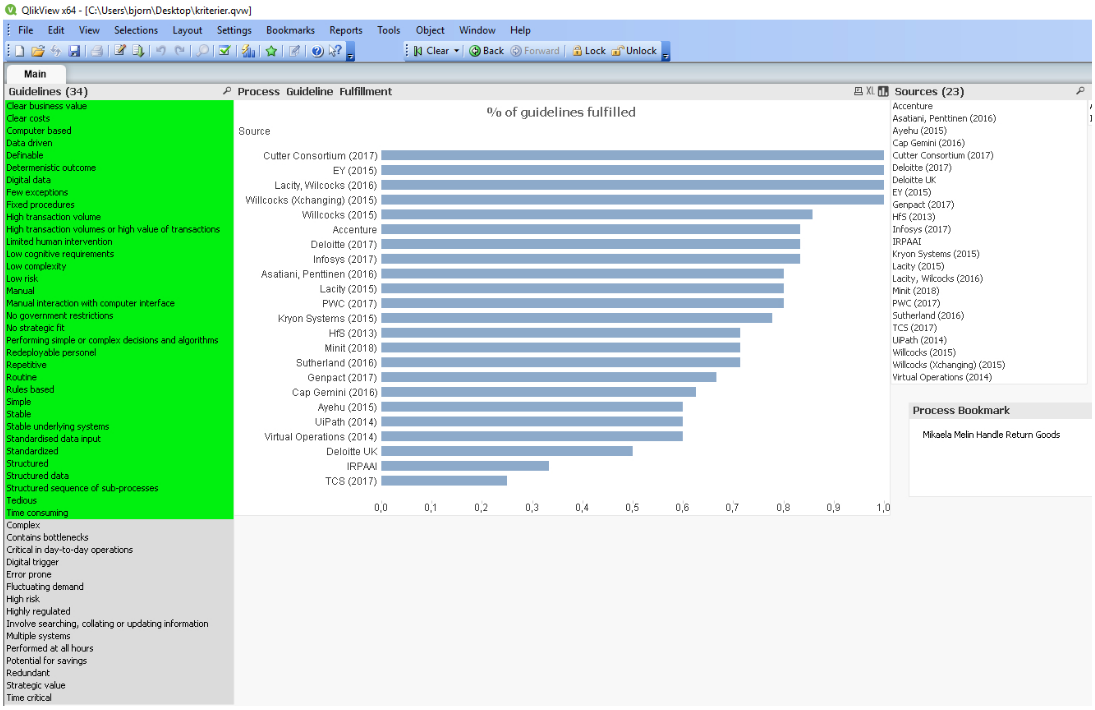

Figure 3.2: Screen shot of the Qlikview application used.

BPMN was analyzed a bit differently. After all four initial processes had been modeled, the use of BPMN for assisting in assessing process suitability for automation with RPA was to be evaluated. This was done qualitatively by identifying aspects that were hard to capture but played a part in the assessment of the process. Mostly this covered areas that had to be explained using plain text or comments in the models, e.g. data related aspects such as data quality. The result of this analysis as well as a general evaluation on how BPMN was to work with for this purpose is described in Section 4.2.1.

3.6 Design of New Method

During the analysis of the existing methods several problems and shortcomings were identified which are described in Section 4.2. The next step was to create a new method for identifying and assessing process suitability for RPA that would solve these identified problems.

The creation of the new method started by examining the problems identified during the analysis of existing methods, mentioned in Section 3.5, and trying to come up with solutions to each problem. This facilitated the identification of criteria that were not useful and could be removed. These were criteria that were either too trivial or too ambiguous.

The categorization using the affinity diagram, discussed in Section 3.5, was used as a base when deciding upon categories for the new method. After deciding upon categories, all criteria were assigned to a category. Which criterion that ended up in which category depended on the detail level of the criterion and the way the criterion was supposed to be assessed. An example of the latter is the difference between mandatory and optional criteria.

Finally, criteria that have not been mentioned by any source but identified by the researchers were also added to the new method. These new criteria, discussed in Section 4.2.7, were discovered during the process of modelling and analyzing the processes from the first round of interviews.

The new method also included a step where the process should be modeled. Since the method was meant to solve the problems identified this was done by adding an extension to BPMN, targeting the identified shortcomings of using regular BPMN for this purpose. This new extension was called BPMN-R and is described in Section 4.3.2.

This new method that was developed during this phase came to be called the RPA Suitability Framework and will be referenced as such through the rest of this report. See Section 4.3.1 for a description of the framework.

3.7 Applying the New Method

After the new RPA Suitability Framework was designed, the next step was to try it out in practice. Like with the initial application of existing methods, covered in Section 3.4, this was done by applying it to processes from the partner company, in order to see how the new methodology worked in a business environment.

The framework was applied to a new set of processes that were not covered in the first round of interviews. These processes were derived from a second round of interviews, which were carried out in the same semi-structured manner as in the first round but with another interview script, found in Appendix G. The new script was modified to fit the new framework, with some differences in questions but mainly a new order and focus of how the questions were asked. The different areas of business value that can be achieved with RPA, described in Section 4.3.1, was used as a source of inspiration for identifying possible processes that could be of interest. During the interviews, five processes were identified and selected for testing the new RPA Suitability Framework. The selection of which processes that the framework should be applied to was based, just like in the first round, on how well the processes were described so that they could be modelled and assessed using the framework.

When the RPA Suitability Framework was applied, the procedures that it suggests were followed. To see a description of these steps, see Section 4.3.1. The first step includes evaluating the risk level associated with the process. Then followed an evaluation of what business value automation of the process would provide. Third the process was modelled using the new extension for BPMN, called BPMN-R, 4.3.2. Finally the process was assessed using the mandatory and optional criteria of the framework.

To enable the comparison between the RPA Suitability Framework and existing methods that were used before, they were all applied to the group of processes that they had not been used on before. That is, the methods used in Section 3.4 were applied to the processes found in this new round and the RPA Suitability Framework was applied to the processes identified earlier in Section 3.4.

After the RPA Suitability Framework had been applied to all processes, a validation meeting was held with the process experts of each respective process. These meetings were performed in a similar fashion as those in Section 3.4, where the interviewee was first shown the process model and then the assessment using the criteria, the different risk levels and the business value that could be found. This was done to ensure that the processes had been understood and modelled correctly as well as assessed in a reasonable way.

3.8 Evaluation of the New Method

Once the new RPA Suitability Framework was tested in practice it had to be evaluated to see if and how it improved on previous methods. This was done in a couple of ways. Firstly, the results of the assessment was compared when it came to whether or not a method would approve of a process being automated with RPA. This was done to see if the outcome of the previous methods were different from that of the RPA Suitability Framework.

But it is not enough to only look at the final recommendation from a method in regards to process suitability as it does not go into detail about why a method would or would not recommend to automate a process with RPA. Therefore the second point of comparison looked in depth at six methods that were used in the study and compares them with the RPA Suitability Framework. This comparison focused on how the RPA Suitability Framework is different from the criteria of the other methods and if it is an improvement. When it came to selecting the methods for comparison, one was requested by the partner company as they were interested in how that source compared to the RPA Suitability Framework. The other five were chosen to give a wide coverage of both industry and academic sources as well as a spread of criteria.

A workshop where the new framework was evaluated was also carried out. The workshop was carried out in collaboration with two RPA experts from the partner company. One of the experts had been involved in the company's first RPA project which was carried out in another division. The other expert was responsible for the RPA project in which the company needed assistance in selecting processes. Before the workshop, a script containing the main questions that needed answers was produced. The script can be seen in Appendix H. The whole workshop was recorded to make sure no important parts were missed out.

The workshop started with a background which presented the identified issues with existing methods. Then the new framework was presented along with how it potentially could solve the identified issues. A discussion followed where the RPA experts could provide feedback and their opinion on the framework.

4
Results

The results from the study are presented in this chapter, divided by the three phases of design research. First, the results from the problem identification phase are presented, then the outcome of the design phase and finally the results of the evaluation phase.

4.1 Problem Identification Phase

The goal of the problem identification phase was to understand the problem, which could be divided into two parts: the problem the partner company faced when trying to select processes to automate using RPA and the problem of using existing methods to assist in this selection. This section will go through results of the interviews and the modelling and evaluation of processes while Section 4.2 will cover the problems that were found with BPMN and existing selection methods.

4.1.1 Existing Methods for Evaluating Processes

By reviewing the subject, a number of sources could be identified that presented existing methods for assessing process suitability for RPA. The consolidation of these methods is described in Section 3.3. Figure 4.1 exemplifies the criteria in the methods presented by two sources. The complete list of criteria per source can be found in Appendix D.

Willcocks[5]	HfS[36]
Clear business value	Multiple systems
Clear costs	Error prone
Stable	Rules based
High transaction volume	Limited human intervention
Multiple systems	Few exceptions
Rules based	Clear costs
Standardized	High transaction volumes or high value of transactions

Table 4.1: Examples of two sources and the criteria included in their methods for assessing process suitability for RPA.

Part of the task of consolidating the criteria was understanding or interpreting their meaning, as the descriptions from the sources varied in how extensive they were. To show what is meant with each of the 49 criteria that the consolidation resulted in, a list of all 49 criteria and the description that has been used is included in Appendix E.

4.1.2 Initial Round of Interviews

In order to understand the problem that the partner company faced and to gather processes that could be modelled and evaluated, a series of semi structured interviews were held, as described in Section 3.4. During this phase, 12 interviews were held along with a number of more informal meetings that helped with understanding the difficulties the partner company faced.

The initial meetings were aimed at increasing the understanding of the problem that the partner company faced when it came to deciding which processes to automate, but also proved to be a valuable source of information that was used in the design of the new method. Specifically the meetings revealed the RPA strategy of the three case companies that the partner company had consulted before beginning their own implementation. An interesting finding was that while two of the companies recommended the partner company to focus on simple processes to quickly get going, one company mentioned that they started with a very complex process. This was done on the request of one of the managers at that company who wanted to be convinced that RPA could be used to automate their complex processes. If successful, the manager would be reassured that RPA could be used to automate simple processes as well further down the line.

The semi structured interviews were also held to identify and describe processes that could be used to evaluate existing methods on. The interviews were recorded and the result has been summarized in Table 4.2. As can be seen in the table, a total of five processes were found that could be captured in enough detail to be modelled with BPMN and evaluated using existing selection methods. However, the process that was found in interview #5 was scrapped after discussions with the partner company as they believed it was too insignificant to be considered. That left four processes that were later modelled and evaluated using the list of 49 criteria found in Appendix B. These four processes are briefly described below in Table 4.3.

#	Role	Findings
1	Head of Strategic Global Sourcing	Possible processes within department
2	Human Resources Manager	Possible processes within department
3	Business Systems Group Manager	No suitable processes identified
4	SHEQ Manager	No suitable processes identified
5	Production Leader	1 well described process, importance of digital data
6	Logistics Manager	Possible processes within department
7	Production Planner	Value of automation during off-hours
8	Assistant Business Controller	2 well described processes
9	HR Professional	1 well described process
10	Global Category Manager	No suitable processes identified
11	Project Lead Buyer	1 well described process
12	Finance Manager	No suitable processes identified
13	Logistics Manager	Possible processes within department

Table 4.2: Summary of the main findings from the semi structured interviews.

#	Process	Interview	Description
1	Price Update	8	Updating the purchasing cost of an item within the ERP system.
2	Invoice Services	8	Sending invoices to customers for services performed. More complex than it sounds due to the ERP system only being configured for manufacturing with no invoicing capabilities.
3	Create Purchase Info Record	11	Setting up the necessary information in the ERP system to allow for purchasing an item.
4	Add Employee in HR System	9	Adding or updating employee information after signing a new contract.

Table 4.3: Brief description of the four processes found after the initial round of interviews.

4.1.3 Modelling and Evaluating Processes

After identifying four processes, described in Section 4.1.2, that were of interest to the partner company, the next step was to model these and apply existing selection methods to see if the processes were suitable to be automated with RPA or not. This section includes some of the models while the rest are placed in Appendix I.

The application of the criteria was described in Section 3.4 and the result for each process can be found in Figure K.1 in Appendix K. The issues that were identified with the application of these existing methods are described in Section 4.2.

Figure 4.1 shows a BPMN model of process 4. This model, along with all other models created during this phase, followed BPMN guidelines as close as possible in order to test how BPMN could be used to assist the assessment of process suitability for RPA.

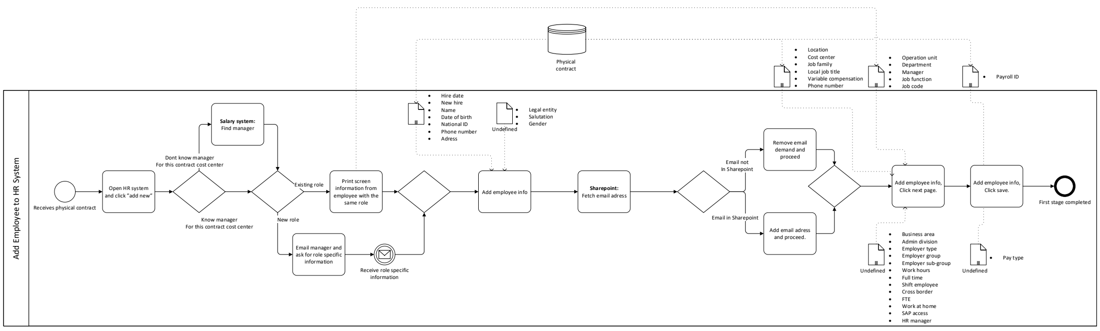

Figure 4.1: BPMN model of process 4, adding an employee to the HR system.

4.1.4 Validation Interviews

After modeling and applying criteria to the processes captured during the first interviews, validation interviews were held to summarize the researchers' work and validate that they had an acceptable understanding of the processes. Each interview was held with the same process expert that participated in the first corresponding interview.

The interviews resulted in some minor changes in the models. All models that are presented in this study are the revised versions. Presenting and discussing the list of criteria with the process experts also assisted in assessing the significance and usability of each criteria.

4.2 Issues with BPMN and Existing Methods

During the problem identification phase, processes were described using BPMN and evaluated using existing criteria as stated in Chapter 3. This revealed a number of shortcomings, both in the criteria but also with BPMN. All issues will be discussed in detail in the following sections but a brief summary is given here for issues found with BPMN and the criteria respectively.

While BPMN was helpful for understanding the processes it was hard to express some aspects in a good way. Most notably were the following issues:

1. Difficult to describe data related aspects of the process such as data source, how structured the data is and the nature of the inputs.
2. Difficult to model decision points except using the gateways which might not always be preferable.
3. Not a clear way to show within which system a certain action is taking place.
4. It is quite time consuming to model a process, which can be a problem if there are many processes to be assessed.

There were also a number of issues with the criteria that were used to evaluate the processes. These issues can be found in the list below:

1. There is a wide spread of which criteria that are proposed by different sources.
2. There is a lack of uniformity when it comes to how the criteria are formulated. The inequality makes the criteria incomparable.
3. There are criteria that are similar with only slight differences.
4. Some criteria are contradicting each other. This is likely due to different sources having different perspectives and strategies when it comes to automation.
5. Some criteria are too trivial to help assess the suitability of a process.
6. Some aspects that seem important for assessing suitability for RPA are not covered by any sources.

This section will go through the different issues and look at them in more detail. Section 4.3.1 describes the new method that attempts to solve these issues and Section 4.3.1.2 provides the justification of this method by showing how the different issues were handled.

4.2.1 Issues with BPMN

When modelling the processes a number of issues with using BPMN were found as described in the previous section. This section will now take a more detailed look at these issues and show how they manifested themselves.

Hard to model the data aspect: BPMN includes a few elements that can model data that is used in the process, but these proved to not be sufficient. Figure 4.2 shows how the data used in process 4 was modelled. The data objects that can be seen in the figure do convey some information about the data but it is not obvious in what format this data comes in. In this process, some data came from the physical contract, some from the salary system and some other data had an undefined source.

While this could be expressed in textual form, there is already a lot of text in the model which could affect the immediate readability of it.

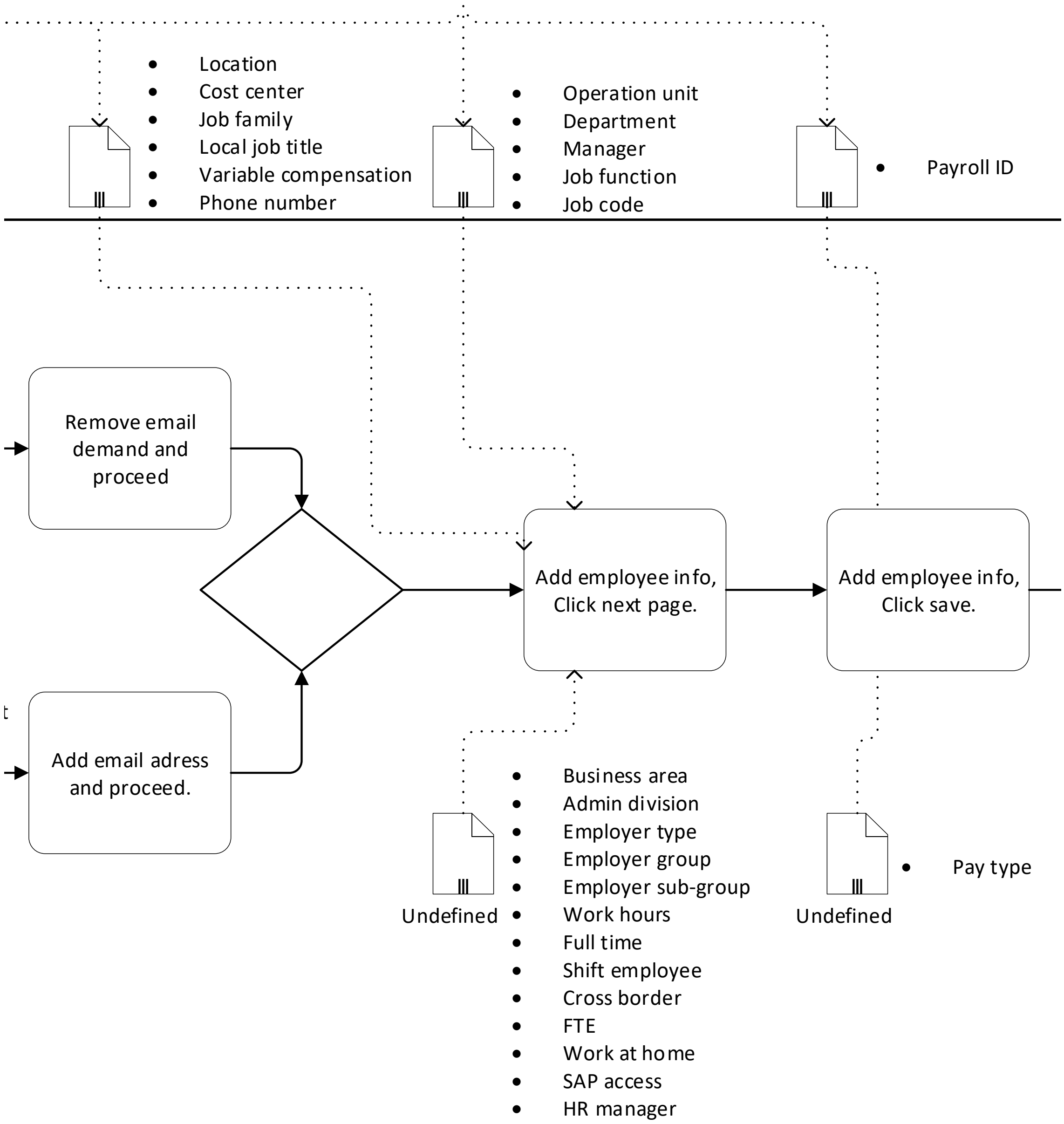

Figure 4.2: Showing the difficulty of conveying data aspects with BPMN, primarily data quality and data source.

Hard to model decision points: Modelling decisions is important when it comes to assessing whether or not a process is suitable for RPA. A decision is seen as something where it is up to the person performing the process to decide what to do, which is in conflict with criteria such as *Rules based* and *Limited human intervention*. Therefore a process containing many decisions might be hard to automate using RPA. However, BPMN does not offer a clear way of highlighting these decisions.

While the gateway element in BPMN can be used to model decisions, it is not necessarily the best way of representing it. Gateways are used to split the flow of the process into different paths, but this split might not come from a decision. Figure 4.3 below shows part of the model for process 1 where the controller enters the procurement type for the item which should get a new price. Depending on the procurement type, the flow of the process differs. However, this is not a decision as the procurement type is already known. Therefore, the gateway is not always a good indicator of a decision taking place.

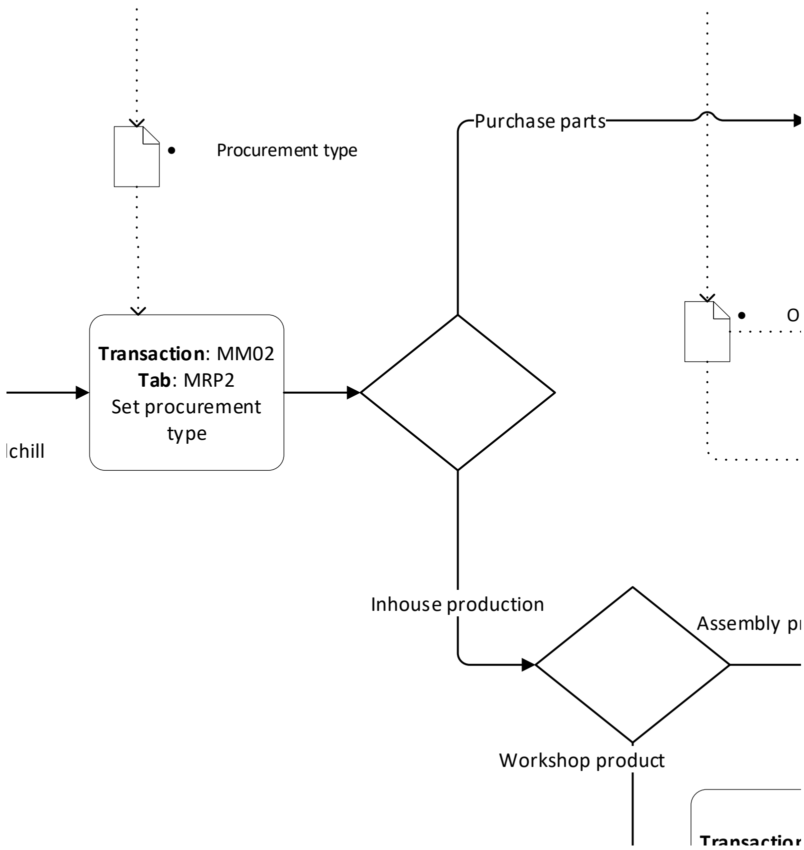

Figure 4.3: Part of the model for process 1 showing how gateways do not equal decision.

Showing which system a task is performed in: Another issue that was discovered was how to show within what system a certain task takes place. This was a reoccurring situation and BPMN provides no clear guideline for how to address it. The situation can be seen in Figure 4.4 where the HR professional would use three different systems during the process. BPMN does have the concept of lanes that can be used to show how different elements of a process are divided, but this is most commonly used to show different roles. While it could be used to show different systems it is not clear how that should be combined with other divisions such as roles.

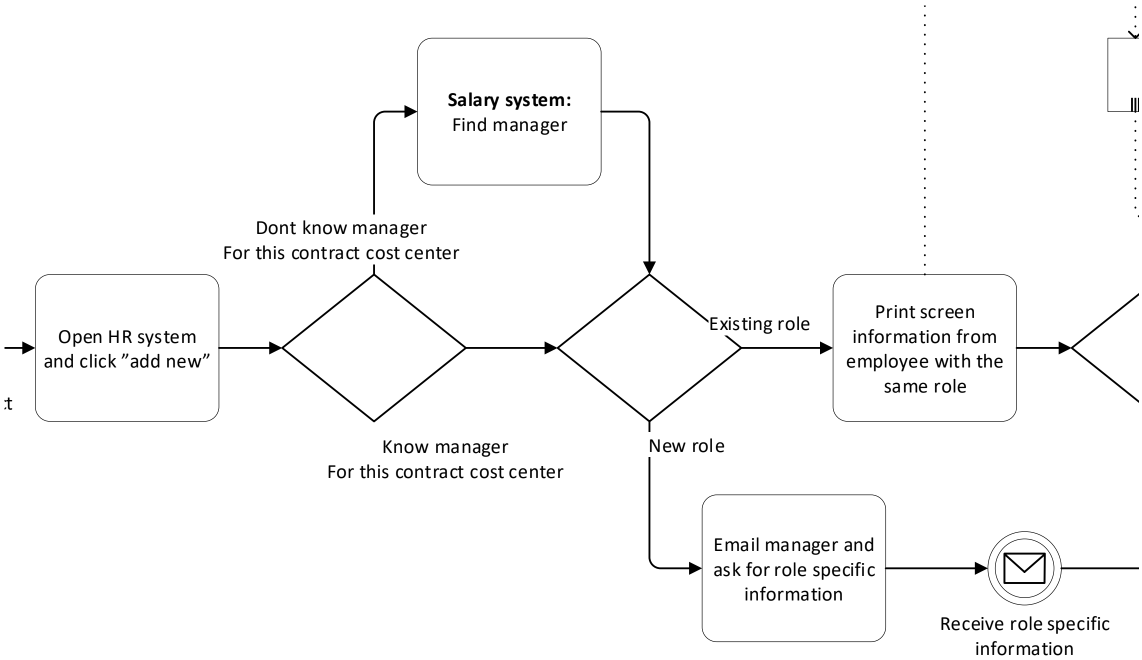

Figure 4.4: Different tasks taking place in three different systems. The HR system in the middle, the salary system in the upper activity and the Email client in the bottom activity.

Modelling is time consuming: Using BPMN to create detailed process models is time consuming. Unfortunately, this might be unavoidable and a downside to any modelling endeavour. It is included here to point out that downside, but it will not be addressed in Section 4.3.2 where solutions to the other issues will be presented.

4.2.2 Different Criteria from Different Sources

From the 23 sources that have been used in this study, a collection of 49 criteria were gathered after an initial consolidation, during which criteria that were almost identical were grouped together. A list of all sources and their criteria, after consolidation, can be found in Appendix D. After the consolidation, some criteria were mentioned by almost all sources whereas some only appeared once. Table 4.4 shows the most common criteria.

Criterion	Frequency
Rules based[2], [3], [5]–[9], [16], [20], [22], [23], [25], [29], [32], [40]–[45]	20
Multiple systems[3], [5], [8], [9], [20], [28], [41]–[45]	11
Error prone[3], [8], [9], [22], [23], [28], [32], [42]–[44]	10
High transaction volume[3], [5]–[8], [16], [20], [22], [41], [42]	10
Repetitive[16], [22], [23], [27]–[30], [32], [40], [45]	10
Few exceptions[3], [9], [22], [23], [42]–[44]	7
Stable[5], [7], [8], [16], [20], [27], [40]	7
Limited human intervention[7], [9], [23], [42]–[44]	6

Table 4.4: Criteria occurring in more than 5 different sources.

The criteria that were only found in one single source numbered a total of 27, showing the diversity found in the sources. There is also a spread in the abstraction level or focus of the criteria. Some focus on the technical aspects of the process, some are more targeting the strategy of the company and other are related to the business case of the automation.

Because of the wide spread in which criteria that are suggested, different methods should possibly also have different results when assessing business processes. This could be confirmed when the methods were applied to 9 different processes from the partner company and will be discussed when comparing the existing methods with the new RPA Suitability Framework in Section 4.4.3. This is problematic since using different methods will end up with different processes as a result.

4.2.3 Different Categories of Criteria

With the consolidated list as a base, it could be established that the 49 criteria were not all equal in such a way they could be compared against each other. The list had criteria with different detail level that did not only focus on processes, it included both mandatory and optional criteria and also some criteria that were pointing at the value obtained by automating the process. Table 4.5 shows a few example criteria that belong to these different categories.

Criterion	Comment
Rules based[2], [3], [5]–[9], [16], [20], [22], [23], [25], [29], [32], [40]–[45]	Criteria that is process specific and mandatory
Multiple systems[3], [5], [8], [9], [20], [28], [41]–[45]	Criteria that is process specific but not mandatory
Error prone[3], [8], [9], [22], [23], [28], [32], [42]–[44]	Focus on the value by reducing errors
Tedious[40]	Focus on the value of satisfied employees
Low risk[6]	Has impact on both process- and project level

Table 4.5: A few example criteria that belong to different categories which have different purposes.

Mixing different types of criteria in a method without attaching a specific guide on how to use them can turn out with a result where unsuitable processes are selected. For instance, if a company only selects processes that are *Error prone*, they might miss out on process candidates that could easily be automated and retain more resources, even though they are not prone to error. On the other hand, criteria such as *Rules based* are mandatory for all processes as it relates to characteristics needed for RPA to be possible.

4.2.4 Criteria with Similar Meaning

Another issue that was found was that some criteria were hard to distinguish from each other but also hard to combine straight away as there are subtle differences between them. It is possible that these differences are due to the specific words chosen by the sources to describe the criteria but it is also possible that the subtleties are intentional and should therefore not lightly be discarded without analysis. The criteria that were seen as problematic due to being similar to others are listed below:

- Definable[3], [40], fixed procedures[8], structured[27], [29], [45] and structured sequence of sub processes[41]
- Manual[8], [22], manual interaction with computer interface[6]
- High transaction volume[3], [5]–[8], [16], [20], [22], [41], [42], high transaction volume or high value of transactions [9] and time consuming [6], [8], [25], [40]
- Limited human intervention[7], [9], [23], [42]–[44], low cognitive requirements [3]
- Clear business value[5], clear costs[3], [5], [9] and potential for savings[6]
- Repetitive[16], [22], [23], [27]–[30], [32], [40], [45] and routine [2], [3]
- Simple[25], [41] and low complexity [16]
- Deterministic outcome[2], data driven[40] and rules based[2], [3], [5]–[9], [16], [20], [22], [23], [25], [29], [32], [40]–[45]

4.2.5 Contradicting Criteria

While the previous issue was with similar criteria, this issue has to do with criteria that are complete opposites. Some sources have presented a specific criterion and in a number of cases another source has presented another criterion which is the exact opposite. The contradicting criteria are listed below:

- Complex[40] and low complexity[16] or simple[25], [41]
- Low risk[6] and high risk [30]
- Strategic value[23] and no strategic fit[42]

These criteria present an issue since the different methods will point at a completely different set of processes.

4.2.6 Trivial or Insignificant Criteria

Some criteria failed to make any impact on the assessment due to being too bland or trivial. Any process that is being considered for automation would likely fulfill the following criteria, making them unsuitable to be used for evaluation purposes:

- Definable[3], [40]
- Computer based[45]
- Manual[8], [22]
- Manual interaction with computer interface[6]
- Performing simple or complex decisions and algorithms[45]

It is important to highlight that this does not mean that a *definable* process is unsuitable. It rather means that definable does not specifically help in identifying or assessing processes since undefinable processes will not be taken into account in the first place. Neither will physical processes that are not *Computer based*, with the same reasoning.

These issues were identified early while collecting existing methods and validated when discussing the criteria with process experts during interviews.

4.2.7 Criteria not Mentioned by Sources

On several occasions while modeling the processes, it was found difficult to express the source of the data in the process and aspects regarding the data quality. This turned out to be problematic when deciding on complexity, which can differ significantly depending on how difficult it is to access the data used by the process. While there are criteria such as *digital and structured data* covering the quality aspects as well as saying that the data should be digital there are no criteria regarding how easily accessible the data is. Therefore a new criteria was added: *easy data access*, which will be discussed in Section 4.3.1 when the new framework is presented.

4.3 Design Phase

During the design phase a new methodology was designed to resolve the issues found during the problem identification phase. This involved two different aspects, the methodology itself which would help with the issues found with selecting suitable processes and an extension to BPMN to better support the assessment.

4.3.1 New Framework for Assessing RPA Suitability

This new framework was called the RPA Suitability Framework and consists of a five step approach which can be seen in Figure 4.5. The elements in the framework and how they should be used are described in Section 4.3.1.1. A justification of how the framework is constructed is found in Section 4.3.1.2.

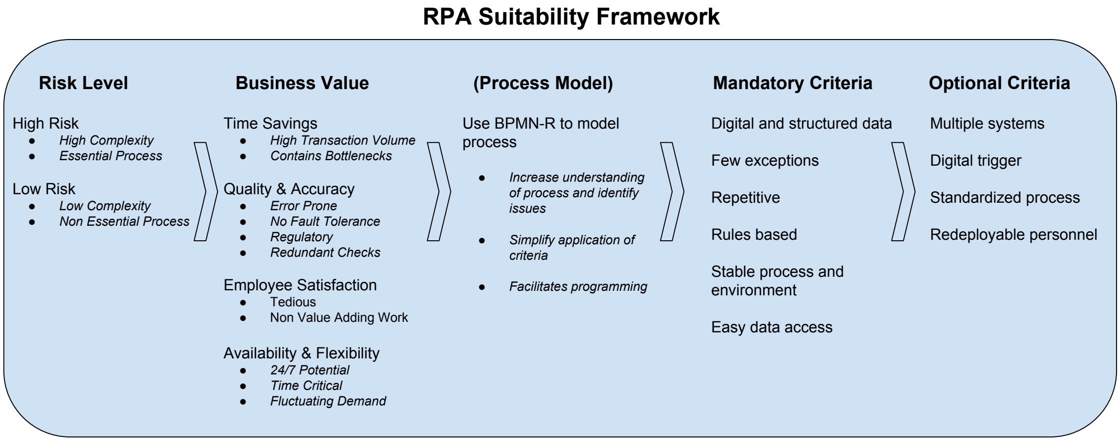

Figure 4.5: The new proposed framework for assessing business process suitability for RPA.

4.3.1.1 Description and Usage of Framework Elements

The framework includes five steps which should be performed in order from left to right. The steps should together ideally work as a funnel, starting with many processes to the left and each step filtering out processes in order to reach a few candidate processes to the right. Below is an explanation of each step and its' included elements.

Risk Level: The risk category focuses on the risk of automating the process using RPA. This has been broken down into two main factors: process complexity and whether the process is essential for the company's operations or not. The high risk level is characterized by processes that are essential and complex, while the low risk level includes non essential processes with low complexity. If a process is a mix of the two, for example an essential process with low complexity or a non essential process with high complexity, the resulting risk level is harder to discern. In these cases an individual assessment of the risk level for the specific process should be done, based on which factor is deemed most important.

A complex process increases the risk since it increases the difficulty of the implementation and an essential process increases the risk as there is more at stake if the automation does not work correctly. However, since there might be more to gain from automating a key process that also has a high complexity, some companies might choose to go for a high risk strategy. Therefore the choice of strategy comes down to level or risk the company is willing to take and the competency they possess. If the company possess experienced people who have worked on similar projects before it might be reasonable to tackle higher risk projects. But for a first timer it is probably better to focus on a process with low risk level. The importance of this step is to find a suiting risk level and a corresponding balance in complexity, which is highly company specific.

Business Value: Before performing a detailed investigation of every process in an organization, it is key to identify the business value for automating a process. If a process would not achieve a clear business value by being automated, there is no need to spend resources on automation. The requirement for a process to proceed to the next step in the framework, is to have potential value in at least one of the following categories:

- Time Savings: This value is often found in processes that are performed often or takes a lot of time to perform. Processes can also be sped up by automating segments that contain bottlenecks, thereby raising the throughput.
- Quality & Accuracy: This value is obtained by raising the quality and thereby limiting rework or rejections and removing delays because of these. With a robot performing the process, the need for checks to secure quality is reduced or even removed.
- Employee Satisfaction: This value is obtained by making the workforce focus on meaningful and value-adding work. An important factor is to make sure the personnel is redeployable so it does not end up with nothing to do and can not be let go.
- Availability & Flexibility: It can be valuable to be able to scale up and down the workforce depending on current demand. If a process can be automated it might also be possible to perform it around the clock, which can have certain benefits. Furthermore automation can be useful for a process that needs to initiate straight after it has been ordered to start, since it does not require the availability of an employee.

Process model: This step is optional as it can be quite time consuming and not necessary in order to assess business process suitability. The type of process modeling that was used in this study did not directly assist in assessing RPA suitability but was still beneficial when carrying out other steps. The benefits from using a process model in combination with the other steps are:

- Creating a process model greatly enhances the understanding of the process, which assists in applying the criteria in the next step appropriately.
- A process model facilitates finding issues with the process, such as poor data quality or complicated data access.
- A process model maps out all the decision points which facilitates assessing their complexity.
- A process model can be helpful when programming the robot that will perform the process.

The RPA Suitability Framework proposes that this modelling should be done using an extension of BPMN called BPMN-R, which is described in Section 4.3.2. This extension includes better capabilities for describing data quality aspects, decision points as well as clear guidelines for showing different systems.

Mandatory criteria: In this step, a candidate process needs to be evaluated with regards to the mandatory criteria. For a process to pass on to the next step in the framework, it is required to satisfy all criteria. If a process can be re-engineered to pass the criteria it might be an option, given that the re-engineering does not require too much resources.

- Digital and structured data: The need for digital data is self-explanatory. Without structure, the robot might need human assistance when interpreting data. Human intervention should be minimal. This changes if the RPA engine has advanced features to interpret data.
- Few exceptions: For each exception, the robot needs additional programming to deal with it. The automation can have reduced performance as a result and the implementation will be more expensive.
- Repetitive: There is no need to automate processes that are not recurring. A process should be performed in the same way over and over.
- Rules based: The process should preferably have as few decision points as possible and the decisions that exist should be able to be solved by establishing simple rules.
- Stable process and environment: The process should not have any upcoming changes or be prone to change. The same rule applies to the systems used in the process, which should be stable and not have major changes when updated.
- Easy data access: There should be well established and easy ways to access all data that is used in the process.

Optional criteria: While the mandatory criteria express properties that the process should have to be deemed suitable for RPA, the first three optional criteria cover areas where good candidates often are found. The last criteria listed is important in circumstances where it is not possible to dismiss people from their job. However, just as the rest of the optional criteria, it is not mandatory.

- Multiple systems: RPA is well suited for processes that uses multiple systems as it can switch between them just like any user.

- Digital trigger: If the process is initialized by a digital trigger it is easier to fully automate the process and remove all human interaction.

- Standardized process: The more standardized the procedures of a process are, the easier it is to map the process. If different people perform the steps of the process in a different manner, it is harder to get a good understanding of the process. Having a single defined way of doing everything makes it easier to program the RPA for working with the process

- Redeployable personnel: If the personnel working with a process cannot be retasked to something else it can be hard to reap the benefits of the project. Many times a robot might not replace an entire full time employee, but rather save some time here and there, creating the need to redeploy personnel.

4.3.1.2 Justification of Framework

The framework was designed with the goal to solve the identified problems that were presented in Section 4.2. This section will go through each problem and explain how it is addressed in the framework. Each solution to a problem will also be justified.

Different criteria from different sources: The main issue with existing methods is that they show a wide diversity in which process characteristics that are deemed important. The framework address this issue by collecting and including criteria mentioned by different sources. By doing this, the framework captures the criteria that are mentioned by many sources but also the long tail of criteria that are only mentioned once or by a few sources. In order to do this without making the framework too cumbersome to use, many criteria had to be removed or merged from the initial consolidation. Table 4.6 shows the mandatory criteria from the framework and the tracing from the initial consolidation. A thorough tracing from the original source to all of the elements in the framework can be found in Appendix A, B and C.

Framework mandatory criterion	**Compiled from**
Digital and structured data	Digital data, Digital and structured data
Few exceptions	Few exceptions
Repetitive/Routine	Repetitive, Routine
Rules based	Data driven, Deterministic outcome, Limited human intervention, Low cognitive requirements, Rules based
Stable process and environment	No change due to regulations, Stable, Stable underlying systems
Easy data access	-

Table 4.6: Mandatory criteria from the framework and their original criteria from the consolidated list. Only the criterion "Easy data access" has no tracing since it was introduced by the researchers and has not previously been discussed by any sources included in this study.

Different categories of criteria: The framework contributes by separating the criteria into the categories that were identified. It was problematic to express the criteria without the categories since it then appears like they should be used in the same manner, which is not the case. For instance, *Rules based* is a mandatory criteria that should apply to all processes that are candidates for RPA. *Error prone* is not a mandatory criteria but rather a guideline for finding suitable processes. These two can not be used in the same way but are still valid criteria. This reasoning justifies the creation of criterion categories that are applied differently and used in separate phases of the RPA project. These categories are presented as the different steps in the framework (except for "Process Model" which is not a step that stems from this reasoning). The reasoning for each step is listed below.

- Risk Level: This category stems from the contradicting criteria. Choosing between high or low risk is not a question between right or wrong since there are successful cases from both sides. This is supported by the initial interviews with the partner company, see Section 4.1.2, and by sources which promote either side[6], [40]. The category is presented first because the level of risk is not only something to decide on process level but also on project level, before starting the RPA implementation. In other words, if processes with a certain risk level are to be considered, it should match the risk level the project is willing to commit to. Since the framework focuses on identifying candidate processes, the underlying elements (high/low complexity and essential or non essential process) are presented on a process level. That is why the original criteria Strategic value and *No strategic fit* has been renamed to *Essential process* and *Non essential process* to make it clearer that these criteria focus on processes.

- Business Value: Most sources discuss what the value of the automation is, which was written about in Section 2.1. This category was created by using the criteria that capture these different types of value. Some changes has been made to clarify the value that can be obtained:
  - No fault tolerance: This criteria was originally called "High risk"[30] but the source is rather proposing that processes that need to be faultless are better off when performed by robots than by humans. The renaming was therefore done to not confuse it with the risk level.

- Process Model: After carrying out several interviews, the process candidates were modeled before applying the criteria to them. Each created model provided the researcher with more insight about the process. Creating the model before applying the criteria most likely led to a more accurate depiction of each process. This reasoning led to a recommended step in the framework where the process is modeled. It is however, just recommended since it should not be mandatory in circumstances where the person performing the analysis already have an acceptable understanding of the process. Another reason is that if a large number of processes are to be considered, it might not be feasible to create accurate models of them all.

- Mandatory Criteria: This category includes the characteristics that are critical for a process in order to be suitable for RPA. If a process could be suitable without a specific criterion, that criterion was put in another category. Below are explanations of the criteria that has changed from their original state:
  - Stable process and environment: This criterion was created from the original criteria "Stable"[2], [5], [7], [8], [20], [27], [40], "Stable underlying systems"[3], [8] and "No change due to regulations"[27]. The criterion deals with three kinds of stability: The process stability, system stability and regulations' impact on stability. No source included all of these types, which the framework can contribute with.
  - Easy data access: This is the only criteria that has not been mentioned by any of the sources. However, this was something that the researchers had issues with several times while modeling the processes. To make sure that issues with data access are identified before an RPA developer starts coding the robot, this is an important criteria that should be part of the framework.

- Optional Criteria: These are the criteria that describes characteristics of a process that could potentially be left out, while the process still being a valid candidate. However, these criteria describe characteristics that can make a process especially suitable for RPA and should not be ignored. *Multiple systems*, for example, can point to processes where RPA can particularly effective but it is obvious that processes just using a single system can benefit from automation with RPA as well.

Criteria with similar meaning: Some criteria were very similar with only slight differences, even after the consolidation that was described in Section 3.3. While applying all criteria from the consolidated list on the processes from the partner company, the researchers discovered that these lesser differences in criteria did not matter when assessing the process. For instance, each process that had *Limited human intervention* also had *Low cognitive requirements* and each process that was *Data driven* was also *Rules based*. This result justified the merging of similar criteria. Some examples of this can be seen in Table 4.6. The final name for the criteria was chosen as the name that was most frequently used by the sources or a summarizing name that captured the essentials of the criteria.

Contradicting criteria: The issue with contradicting criteria includes criteria which are based on different RPA implementation strategies stated by different sources. Most sources claim that a low risk implementation with simple processes is the best option e.g. [6], [42] but other sources, including a partner to the partner company (see Section 4.1.2) claim that there is more to be gained when taking on a higher risk [40]. There is not a single correct answer to this question but it rather depends on the circumstances for each company. This is therefore not a criteria but rather a choice to be made both on a project- and process level. This is why the risk level step is presented first in the framework since this choice has higher impact on project level than the other steps. The contradicting criteria are actually not a problem, rather different strategies that can work out differently depending on the company.

Trivial or insignificant criteria: Several criteria were removed before creating the new framework. This was due to their incapacity in adding value when making the assessment of processes. The decision of which criteria to remove was taken after the validation meetings with the process experts had taken place. Letting the process experts come with input on the list of criteria that was used justified the researchers decision on which criteria that were removed.

4.3.2 Extending BPMN

The RPA Suitability Framework includes a step called *Process Model* where the process to be evaluated should be modelled. While BPMN was used to model the processes of the partner company, as can be seen in Section 4.1.3, a number of issues with BPMN were identified, as described in Section 4.2.1. This section will present a new extension to BPMN that has been namned BPMN-R, designed to target these issues. Specifically BPMN-R offers the following improvements over using regular BPMN when modelling business processes with the purpose of later evaluating them for their suitability to be automated with RPA:

- Improved description of data quality and data source.
- Clear direction on how to show different systems that are used during a process.
- Specific description of decision points in the process.

Describing data quality: One criteria in the RPA Suitability Framework specifies that the process should use *digital and structured data*. While data can be described in BPMN using *data objects*, BPMN-R goes further. In BPMN-R data objects can be categorized into three categories: physical, digital or undefined. The data within data objects can also be marked as structured using plain text or unstructured using underscore. In Figure 4.6 this can be seen as the three data objects show the different categories and the data for the description is marked as unstructured.

Showing different systems: For this point no new element was added to BPMN-R. Rather, a certain element of regular BPMN was given a more specific purpose to better support the purpose of BPMN-R and make using it more straightforward. This element was the *lane* element, which in BPMN can be used for any type of division but largely is used for depicting roles. In BPMN-R it is solely used to name the process and show the different systems being used. An example of how this could look is seen in Figure 4.6. Note that this removes the use of lanes for other purposes, such as expressing roles. This should not be an issue for the intended purpose of assessing business process suitability for RPA as roles are not as important for a robot as a human employee.

Specifying decision points: The third addition that BPMN-R brings is that it allows to clearly specify decision points. This is important as the *gateway* element in BPMN is often perceived as a decision while it might not always be the case, as discussed in Section 4.2.1. BPMN-R provides a symbol that can be added to *tasks* to show that a decision is required. This symbol is seen in Figure 4.6 as the yellow triangle with an exclamation mark.

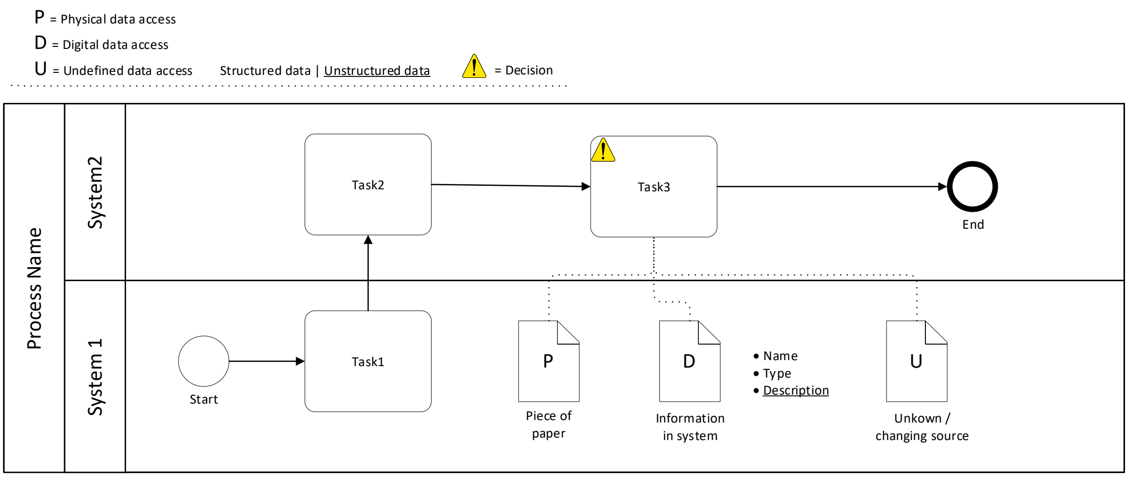

Figure 4.6: BPMN-R example model showing the added elements.

To formalize the additions explained above, a metamodel of these additions and how they fit into regular BPMN is included below in Figure 4.7. The elements marked in blue have been changed or added as described above. Note that the *Lane* element is not in blue. This is as BPMN-R does not change how lanes are represented in the model, only their intention. One addition that can be seen in the model is in the *Activity* element where the attribute of including a decision or not has been added. The *Data Object* element includes the rest of the additions. A new attribute has been included to represent the three categories of physical, digital or undefined data. In Figure 4.7 this can be seen in the enumeration class *Data Source* and the corresponding attribute in the *Data Object*. The *Data Object* also includes any number of lines of data which can either be structured or unstructured. Note that Figure 4.7 does not represent the entire metamodel for the BPMN language, rather it includes the elements relevant for hosting the additions of BPMN-R in a process model.

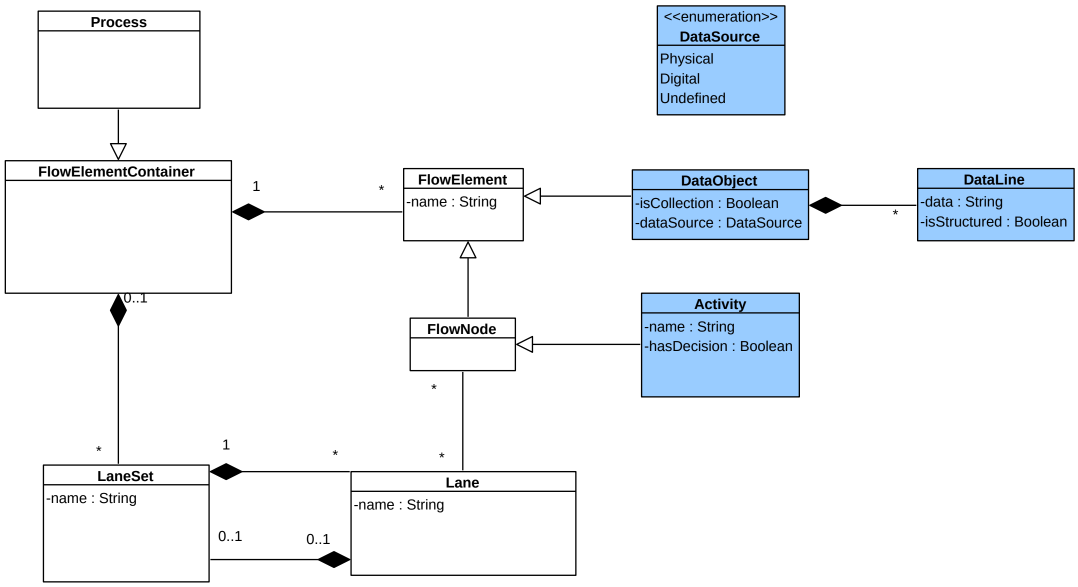

Figure 4.7: BPMN-R metamodel showing how the additions fit within a process model.

4.4 Evaluation Phase

The evaluation of the new RPA Suitability Framework was carried out in two steps. First the method was applied in practice at the partner company as described in Section 3.7 and then it was evaluated as described in Section 3.8. The method was both applied to new processes found during the second round of interviews, described in Section 4.4.1, as well as those found during the previous round. After applying the RPA Suitability Framework, the framework was evaluated in three different ways. First the framework's result of whether or not a process should be automated with RPA was compared with the results from applying existing methods. This comparison is described in Section 4.4.3. Secondly the content of the RPA Suitability Framework was compared in depth against six of the existing methods that were used. The selection of these methods and the comparison is covered in Section 3.8. Lastly, the framework was evaluated during an evaluation workshop where two RPA experts from the partner company participated. The result of the workshop is presented in Section 4.4.5.

4.4.1 Second Round of Interviews

The second round of interviews followed the procedures described in Section 3.7. During this round a total of 12 interviews were carried out with the goal of finding new processes to be modeled and evaluated using the RPA Suitability Framework. It should be noted that interview #18 was performed with the same person as interview #7 from Section 4.1.2. A summary of the result of these 12 interviews are found in Table 4.7.

#	**Role**	**Findings**
14	Product Quality Manager	Possible processes within department
15	Supply Chain Developer	Possible processes within department, importance of rules based processes
16	Master Data Manager, Logistics	1 well defined process
17	Business Intelligence Developer	No suitable process found
18	Quality Engineer	No suitable process found
19	Production Planner	1 well defined process
20	Global Category Manager	Possible processes within department
21	Quality Manager	1 well described process
22	Call Off	No suitable process found
23	Production Leader	2 well described process
24	Logistics	1 well described process, importance of process stability
25	Machine Operator	No suitable process found

Table 4.7: Summary of the main findings from the second round of semi structured interviews.

The interviews revealed a total of six new processes that were described in enough detail for the RPA Suitability Framework to be applied. However, one of the processes from interview 23 was quite similar to the process from interview 19 and was therefore dropped. The five remaining processes are briefly described in Table 4.8, along with the four processes from the first round. These initial processes are also found in Table 4.3.

#	Process	Interview	Description
1	Price Update	8	Updating the purchasing cost of an item within the ERP system.
2	Invoice Services	8	Sending invoices to customers for services performed. More complex than it sounds due to the ERP system only being configured for manufacturing with no invoicing capabilities.
3	Create Purchase Info Record	11	Setting up the necessary information in the ERP system to allow for purchasing an item.
4	Add Employee in HR System	9	Adding or updating employee information after signing a new contract.
5	Handle Return Goods	23	Receiving returned goods from customers within ERP system.
6	Create & Send Credit Memo Notifications	21	Creating and sending credit notes when items are sent back to vendors.
7	Release Production Orders	19	Releasing planned orders for production within ERP system.
8	Goods Receivings	24	Receiving incoming goods from vendors within ERP system.
9	New Material Creation	16	Setting up new material information within ERP system.

Table 4.8: Brief description of all nine processes found during the first and second round of interviews.

4.4.2 Applying the RPA Suitability Framework

The RPA Suitability Framework was applied to the processes extracted from interviews with the partner company. This application will be described in order of the five steps included in the framework. The results from each step on the processes can be seen in Figure 4.8. In order to make a comparison with existing methods, the new framework's criteria were also applied to the processes from the first interview round. With the same reasoning, the criteria from the existing methods were also applied to the processes from the second interview round. To see the assessment using the consolidated list of 49 criteria on the new processes see Appendix K.

	VK update (1)	Invoicing services (2)	Create PIR (3)	Add employee in HR system (4)	Handle return goods (5)	Create/send CMN (6)	Release production orders (7)	Goods Receiving (8)	Create new material (9)
Risk level									
Complexity	Low	Low	Low	High	Low	Low	Low	Low	Low
Essential process	Yes	No	Yes	No	No	No	Yes	Yes	Yes
Business Value									
Time consuming	x	x	x	x	x	x	x	x	x
Quality & accuracy								x	x
Employee satisfaction	x	x		x	x		x	x	x
Availability & Flexibility	x		x				x	x	
Mandatory Criteria									
Digital and structured data	x				x	x	x		x
Few decision points	x	x			x	x	x	x	x
Repetitive	x	x	x	x	x	x	x	x	x
Rules based	x	x	x		x	x	x	x	x
Stable process and environment	x	x	x	x	x	x	x		x
Easy data access	x	x	x		x	x	x	x	x
Optional Criteria									
Mulltiple systems	x	x	x	x		x			x
Redployable personnel	x	x	x	x	x	x	x	x	x
Digital trigger	x								x
Standardized process	x	x			x	x	x		x
Final Recommendation	Yes	No	No	No	Yes	Yes	Yes	No	Yes

Figure 4.8: The results of applying the new framework on the chosen processes from the partner company.

4.4.2.1 Risk Level

After discussing with the people responsible for the RPA project at the partner company, it was agreed that the implementation should follow a low risk approach. This had impact on the interviews where the researchers focused on identifying either *Non essential processes* or processes with *Low complexity.* In cases where one of these did not match the desirable outcome, a qualitatively decision had to be made on the process risk. If both criteria did not match the desirable outcome, that process was not considered.

4.4.2.2 Business Value

The second round of interviews had a different structure since they were based on the new RPA Suitability Framework. The main difference was the initial way of identifying processes, which followed the framework's way of identifying business value. The interviews are described more in detail in Section 3.7. If a process identified either of the business values by being automated, that process continued to the next step.

4.4.2.3 Process Model

After the five processes that were described in Section 4.4.1 had been identified during the interviews, they were modeled using BPMN-R. An example model of an entire process can be seen in Figure 4.9. BPMN-R models for all the processes can be seen in Appendix J. The models provided the researchers with an improved understanding of the processes, which were helpful when applying the mandatory and optional criteria in the next steps.

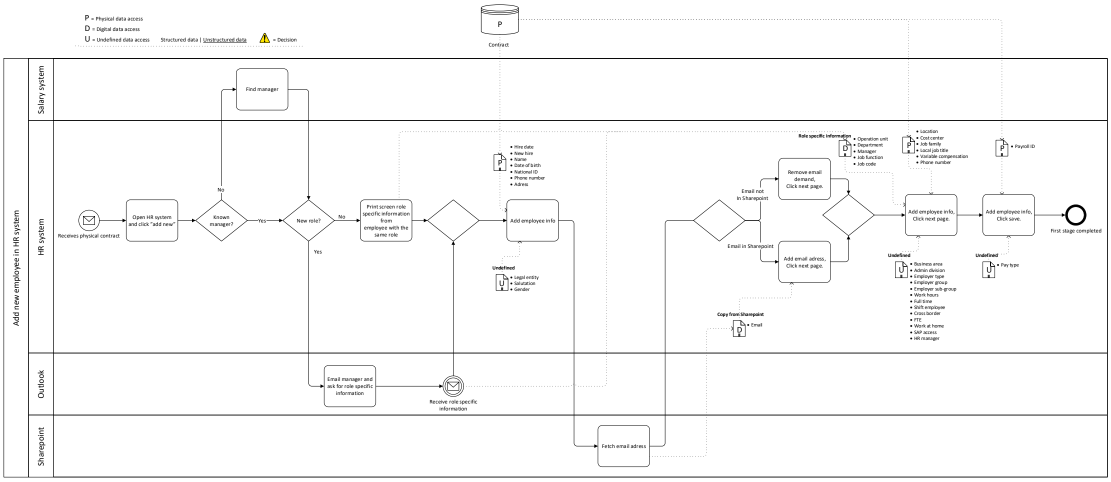

Figure 4.9: BPMN-R model of adding an employee to the HR system.

The modeling turned out to be easier than using regular BPMN. This had to do with learning effects of the researchers but also the added functionality in BPMN-R. One advantage of BPMN-R was the added functionality which could clarify data related aspects of the processes, as seen in Figure 4.10.

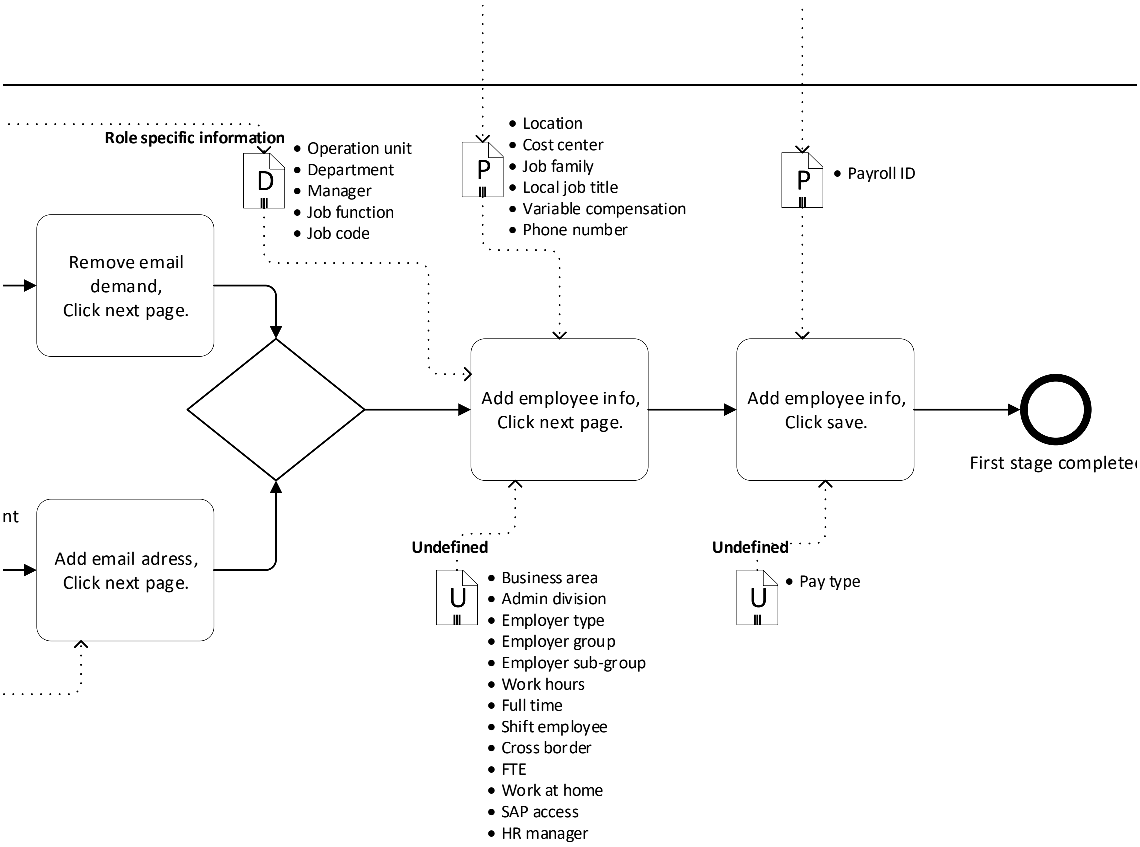

Figure 4.10: Showing the different kind of data objects in BPMN-R.

Another advantage of BPMN-R is that it allows to clearly point out decision points. An example of this is shown in Figure 4.11. Note how the gateway in the figure does not include an actual decision, as it is just checking to see whether or not a number exists. This reaffirms the point discussed in Section 4.3.2 about why there is a need to mark decisions and keep it separate from the gateways.

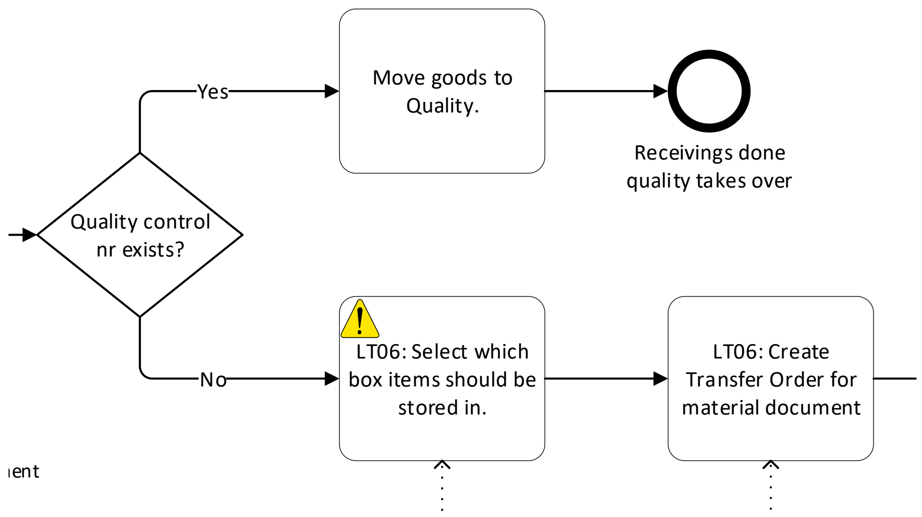

Figure 4.11: The yellow decision marker highlights the decision point in BPMN-R.

BPMN-R also specifies the use of swim lanes to represent systems rather than only roles, which is the most common usage area of swim lanes in BPMN. An example of this can be seen in Figure 4.12.

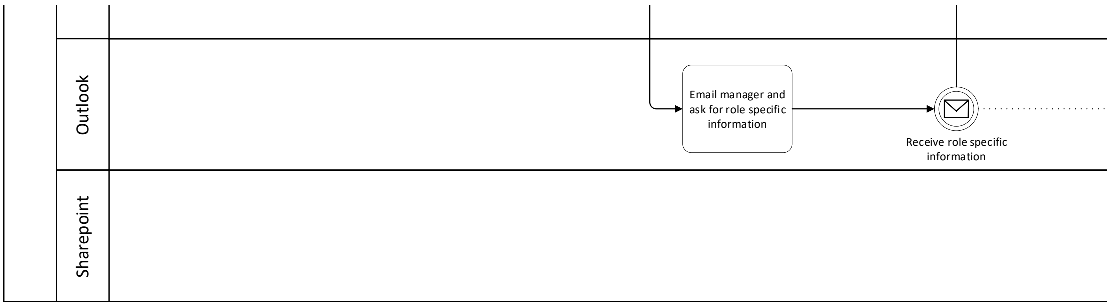

Figure 4.12: Showing how BPMN-R uses lanes to depict different systems.

4.4.2.4 Mandatory and Optional Criteria

Applying the mandatory and optional criteria was done in the same manner as when applying criteria from existing methods. The researchers made a qualitatively assessment which was then validated through interviews with the process experts. The procedures for the evaluation meetings are described in more detail in Section 3.7. The result was then compared with the results from applying existing methods. The result of the mandatory criteria application is the only that can be directly compared with the results of the existing methods since the existing methods do not make a distinction between mandatory and optional criteria. This comparison can be seen in Figure 4.13 in Section 4.4.3.

4.4.3 Evaluating the Results of the Methods

The new RPA Suitability Framework was applied to the same nine processes as that of the existing methods. The first step in the evaluation of the new framework was a comparison of the recommendations from the framework and existing methods, based on the application of the methods' criteria. The results of applying the criteria in the methods to the processes are summarized in Figure 4.13.

Source \ Process	1	2	3	4	5	6	7	8	9
Accenture	100%	67%	67%	17%	83%	83%	83%	50%	100%
Asatiani, Penttinen (2016)	90%	90%	90%	60%	80%	90%	90%	80%	100%
Ayehu (2015)	80%	100%	60%	40%	60%	80%	80%	60%	100%
Cap Gemini (2016)	75%	75%	75%	38%	63%	75%	75%	63%	88%
Cutter Consortium (2017)	100%	100%	100%	75%	100%	100%	100%	75%	100%
Deloitte (2017)	83%	83%	83%	50%	83%	83%	100%	100%	83%
Deloitte UK	67%	67%	83%	33%	50%	50%	50%	67%	67%
EY (2015)	75%	75%	75%	25%	100%	100%	100%	100%	100%
Genpact (2017)	67%	50%	67%	33%	67%	67%	67%	50%	67%
HfS (2013)	86%	86%	71%	43%	71%	86%	86%	71%	100%
Infosys (2017)	83%	83%	83%	50%	83%	83%	83%	83%	100%
IRPAAI	33%	33%	33%	33%	33%	33%	33%	33%	33%
Kryon Systems (2015)	89%	89%	78%	67%	78%	78%	78%	67%	89%
Lacity (2015)	100%	80%	80%	40%	80%	100%	100%	60%	100%
Lacity, Wilcocks (2016)	100%	75%	75%	50%	100%	100%	100%	75%	100%
Minit (2018)	57%	71%	43%	29%	71%	71%	71%	71%	86%
PWC (2017)	90%	90%	80%	60%	80%	90%	90%	80%	100%
Sutherland (2016)	100%	86%	100%	43%	71%	86%	100%	57%	100%
TCS (2017)	50%	75%	50%	75%	25%	50%	50%	50%	75%
UiPath (2014)	80%	100%	60%	40%	60%	80%	80%	60%	100%
Willcocks (2015)	100%	86%	71%	57%	86%	100%	100%	71%	100%
Willcocks (Xchanging) (2015)	100%	67%	83%	33%	100%	100%	100%	83%	100%
Virtual Operations (2014)	80%	80%	90%	60%	60%	70%	80%	50%	80%
RPA Suitability Framework									
Mandatory and optional	100%	80%	60%	40%	80%	90%	80%	50%	100%
Only mandatory	100%	83%	67%	33%	67%	100%	100%	67%	100%

Figure 4.13: The results from applying the criteria from each source and the new framework on the processes. Each method was applied to 9 processes and the percentages show how many criteria from that method that were satisfied by the process.

Figure 4.13 shows in percentages the share of a method's criteria that were satisfied by each of the nine processes. For the existing methods, the criteria that were used can be found in Appendix D. The results show a wide spread between different sources, the spread being in which criteria the sources deem important for RPA suitability.

Regarding the RPA Suitability Framework, described in Section 4.3.1, first both the mandatory and optional criteria were applied. By applying both of these categories, the result can be directly compared with the results from existing methods since these do not make a distinction between mandatory and optional criteria. This is however not how the framework is intended to be used. The last row in the figure shows the result of applying only the mandatory criteria, which is the intended way. The difference in results from these two applications illustrates the issue of not categorizing different criteria in the existing methods. For instance, process 7 is recommended for automation by the intended use of the framework with a result of 100%. When including optional criteria, the result drops to 80%. Some of the existing methods might also have criteria which is not mandatory and without proper classification of these, the assessment can turn out wrong when only comparing percentages of all criteria that are fulfilled.

Figure 4.13 clearly shows that the RPA Suitability Framework comes to a similar conclusion to that of Willcocks, Lacity [2], [5], [16], [20] and to some extent Asatiani and Penttinen [3]. IRPAAI [30] sticks out by being quite different from any other source, including the RPA Suitability Framework.

Another interesting observation is that the assessment of process 4 and 9 are quite consistent across the sources, where 4 is consistently rejected by the sources and 9 is almost always receiving a high percentage of criteria fulfilled. Process 4 involved adding an employee to the HR system and process 9 was the process of setting up material information for new materials within the ERP system. When looking at how the processes were assessed, as can be seen in Appendix K, it is clear that process 4 fails when it comes to half of the most frequently occurring criteria, described in Table 4.4. These criteria included *few exceptions*, *high transaction volume*, *rules based* and *limited human intervention*, which all were properties not describing process 4. This likely explains why it was consistently regarded as not suitable as these criteria occurred in multiple sources. Altogether, 25 of all 49 criteria were deemed to be fulfilled for process 4.

For process 9, on the other hand, a total of 39 out of 49 criteria were deemed to be fulfilled. While most sources seem to approve of this process, three sources stick out with their hesitation: IRPAAI [30], Deloitte UK [32] and Genpact [25]. Six of the ten criteria that the process did not fulfill came from these sources: *contains bottlenecks*, *fluctuating demand*, *high risk*, *potential for savings*, *redundant* and *strategic value*. Of these criteria only fluctuating demand are mentioned by more than one source. Therefore, many of the other sources have much higher percentages of criteria fulfilled in regards to process 9.

4.4.4 Comparing New Methodology With Previous Sources

The second step in evaluating the RPA Suitability Framework was to compare its content in depth with a number of existing methods, as described in Section 3.8. Thus this comparison does not regard any of the results that were presented in the previous Section 4.4.3. The criteria of the methods included in this comparison, along with the criteria of the RPA Suitability Framework are found in Table 4.9. Only the mandatory criteria of the RPA Suitability Framework were included in the table due to limited space, but the full framework is compared and a description of it can be found in Section 4.3.1.

When comparing the criteria of the RPA Suitability Framework with the six other methods in Table 4.9 a number of things stand out. First, while all other methods

Deloitte[6]	HFS[9]	Willcocks[5]	Asatiani and Penttinen[3]	Accenture[7]	Kryon Systems[40]	RPA Suitability Framework
• Manual interaction with computer interface • Rules based • Time consuming • High transaction volume • Low risk • Potential for savings	• Multiple systems • Error prone • Rules based • Limited human intervention • Few exceptions • Clear costs • High transaction volumes or high value of transactions	• Clear business value • Clear costs • Stable • High transaction volume • Multiple systems • Rules based • Standardized	• Routine • Low cognitive requirements • Definable • High transaction volume • Multiple systems • Rules based • Stable underlying systems • Error prone • Few exceptions • Clear costs	• Rules based • Limited human intervention • Digital data • Digital trigger • Stable • High transaction volume	• Rules based • Definable • Data driven • Repetitive • Time consuming • Tedious • Complex • Critical in day-to-day operations • Stable	• Digital and structured data • Few exceptions • Repetitive/ routine • Rules based • Stable process and environment • Easy data access

Table 4.9: Criteria from the selection of existing methods and the new RPA Suitabililty Framework. The new framework only presents its mandatory criteria.

mention business value, although in different ways, they often fail to cover multiple aspects. All sources mention *high transaction volume*[3], [5]–[7], [9], but *error prone* is only mentioned twice [3], [9] and *tedious* is mentioned just once [40]. The RPA Suitability Framework, on the other hand, includes more options for finding business value with RPA, as can be seen in Section 4.3.1, which can help identify RPA opportunities.

Another area where it is clear that the RPA Suitability Framework offers an advantage over the other methods is when it comes to the risk level of automating a process with RPA. Of the six methods that the framework is compared to, only Deloitte specifically talk about risk [6]. Kryon Systems present the criteria *complex* and *critical in day-to-day operations*, which are the criteria that make up the high risk level of the RPA Suitability Framework. It is interesting to see that they propose two radically different approaches to selecting processes for automation with RPA. According to the RPA Suitability Framework, both these avenues are viable but it depends on the situation and especially the competency and RPA maturity of the company. Since it includes both the high risk and low risk approach, the RPA Suitability Framework can be used by more companies than the methods that firmly hold to one approach.

Looking at the criteria that relate more to the process itself, most sources misses out on the data quality aspect, except for Accenture that includes *digital data*[7]. Accenture are also unique in that their list includes *digital trigger*, which has been included in the RPA Suitability Framework as a guideline since it was deemed important but not vital to determining if a process should be automated or not. The data quality aspect is important as was seen during the case study and is the reason that the RPA Suitability Framework also includes the criteria *easy data access*. When it comes to other criteria a similar pattern to that of business value appears. Many sources include good criteria for selecting processes for automation but most miss at least a couple of important ones. *Stability* is one of these criteria that HFS[9] and Deloitte[6] both miss.

The categorization of criteria in the RPA Suitability Framework is another major contribution. Instead of just listing properties that are beneficial for a process to have it divides them into categories. This can be beneficial in a few different ways. It gives a clearer order to how the method should be applied as well as providing an easy way to distribute the responsibility of the assessment. Perhaps different people should assess the risk level or business value of automating a process than those who assess the technical aspects of it.

Based on this comparison of the method proposed in this study with a selection of sources covered in the study some conclusions can be drawn on the contribution of the RPA Suitability Framework. For one it is clear that it is more inclusive and extensive than the lists of criteria from both academic and industry sources. While other methods might contain some good criteria they all fail to cover all aspects of RPA, especially when it comes to finding the business value for implementing RPA.

4.4.5 New Framework Evaluation Workshop

As a final evaluation, a workshop for evaluating the new framework was carried out in collaboration with the two RPA experts from the partner company. The workshop procedure was described in 3.8 and the questions that were asked during the workshop can be found in Appendix H. The results from the workshop can be used for improving the framework in another iteration. Due to time limitations, this has not been done in this study, however the potential improvements are discussed in Chapter 5.

The results from the workshop, structured after the categories of the framework, are described below. An identified limitation that was not on a category level was that the steps are carried out linearly and not iteratively. Depending on how the process of selecting processes is structured, an iterative model might be more beneficial.

Risk Level: The experts agreed that the content of this category was relevant. It was also found appropriate that the category is presented first since it is something that needs consideration on a project level, in addition to decide it on a process level. In accordance with the description in 4.3.1.1, it was pointed out that the risk level depends on the competence regarding RPA, or IT in general, and the resources that are put in the RPA implementation. A new point of view was that the attitude of the personnel has an impact as well. If the personnel is excited, positive and available to the RPA project, the company is able to take on a higher risk. It was also pointed out that choosing complex processes (and succeeding with these) can have a positive impact on how RPA is received, which can be another factor for choosing upon risk level.

Business Value: The business values in the framework had already been presented to the partner company during a previous iteration of the framework and these had been well accepted. It was agreed that there can be different values to achieve with RPA and there are multiple ways of achieving these. Something that was missing in the framework was a way to measure these values. A good way to improve the framework would be to include key performance indexes (KPI) that could measure these values. This is however difficult to include since such KPIs would be highly process specific and obstruct the generalizability of the framework.

Process Model: All of the benefits of creating process models was agreed upon during the workshop. But this evaluation step also confirmed an issue with process modeling that has been discussed previously: modeling is time consuming. In real projects there are rarely enough time to make extensive modeling, at least not with the high detail level that has been performed in this study. It was agreed that there is a need for process modeling but in this step in the framework it should be on a more abstract level to allow more processes to have time to be modeled.

It was also suggested to swap the order of this step and *Mandatory Criteria*. That way, less process candidates would be left to be modeled. The downside of a swap like this is that it removes the advantage of being able to more accurately apply the criteria with a process model as base.

Another point of view that was brought up during the workshop was that there is a point in having two modelling phases, one which describes the process on a higher level and one that focuses on the details. The idea being that the first can be helpful for communicating and understanding the process while the detailed model should capture enough detail to allow for a RPA developer to use it as a specification.

Mandatory Criteria: This category had also been presented to the company previously and the criteria were mainly found relevant. *Few exceptions* should however be in the Optional Criteria category. There can be processes that have many exceptions but are still good candidates for RPA since suitable subprocesses of these can be automated. The last criterion *Easy data access* was conceived as a bit redundant since it might be interpreted from combinations of the other criteria.

Optional Criteria: The first three criteria were well received and considered to be in a suitable place. *Standardized process* was slightly confusing in the partner company context where standardized means to incorporate the use of specific standards. In this case *Aligned process* would have made more sense. The last criterion *Redeployable personnel* was fine in the context of the partner company but could be confusing in other work cultures which have a higher rate of staff turnover where firing of personnel is not an issue.

5

Discussion

This section will start by looking back to the research questions defined in Section 1.1.1 to see how they have been answered in this study. These questions covered the use of existing methods in determining process suitability for automation using RPA as well as suggested improvements over these methods. This section will also relate this thesis to the field of study and suggest future work. Some specific attention will also be placed on the future of RPA and how technological changes impact the conclusions made in this study. Finally, threats to the validity of this study will be discussed and any limitations to the work or its generalizability.

5.1 RQ1 Suitability of Existing Methods

The existing methods have shown shortcomings in various ways that were all mentioned in Section 4.2. The most significant of these is that different sources suggest different criteria when assessing process suitability for RPA, which will turn out with different results depending on which source that is chosen. This issue, along with the other shortcomings, e.g. different types of criteria used the same way or some criteria that add nothing to the actual assessment, makes the methods insufficient to be used on their own.

BPMN proved to be a useful tool to help understand the processes but it also failed to cover several aspects that are important for assessing RPA suitability, especially aspects regarding data source and data quality. While BPMN can assist in understanding a process, it can also be too time consuming to create process models, with the detail level chosen in this study, if there are many processes. Process models with this detail level may not be worth the time it takes to create them.

5.2 RQ2 Suggested Improvements to Existing Methods

Most of the existing methods have different ways of performing the suitability assessment. The existing methods need an improvement to the wide spread that they present, which could be done by consolidating the criteria. The criteria in the methods also need to be handled differently depending on the nature of the criterion. Insignificant criteria also need to be removed in order to allow important criteria to be focused.

In order to assist further in assessing RPA suitability, BPMN needs better ways of expressing different types of data and the source of this data. It also needs a way to more clearly express decision points, where the gateway element proves to be insufficient.

What remains unclear is which level of detail in BPMN that is best suited for RPA purposes. The detail level that was presented through BPMN-R was helpful in the context of this study but a more abstract process model might be sufficient if the RPA project is subject for time limitations. BPMN-R will probably be useful when there is an uncertainty of how the process works, but less useful if the process is well understood or without complexity. This is however also highly depending on the people involved. If the people responsible for building the RPA are not involved in the assessment, it might still be necessary to have a detailed process model, or some other highly detailed specification, to be able to state what the RPA must be able to accomplish.

5.3 Contributions to the Field and Future Work

The RPA Suitability Framework was created as an approach to cover the needed improvements on existing methods that was described in the previous section. Its biggest contributions are the collection of significant criteria and the categorization of criteria which points out a good range of business value opportunities. It also observes the aspect of data access, which has not been presented by other sources included in this study.

Another contribution is the consolidation of criteria from existing methods. Although this does not cover all sources within the field, it shows some of the width of criteria being suggested. A more extensive literature review could be in order to see if the trends discussed in this study hold true for the vast majority of selection methods. It is not clear why sources from the RPA industry have not consolidated criteria before this but rather have presented different views of what to focus on. An explanation could be that they are commercial players that benefit from presenting an exclusive method for selecting processes.

The framework however needs to be tested more extensively. Especially by using it to select processes and actually implement RPA for these processes. Measuring whether the selection was successful or not would significantly raise the validity of the framework. This was something which could not be done in this study due to time limitations.

The framework will most likely also benefit from future iterations which update its content. The field of RPA is changing with a fast pace and the framework will need to keep up to stay relevant. This is discussed further in Section 5.4 but some areas, which are summarized below, have already been identified during the workshop described in 4.4.5.

1. It could be beneficial to put the step for applying mandatory criteria before the step of creating a process model.
2. Include KPIs for the business values. It can be difficult to create generalizable KPIs but if it is possible, the framework would benefit from it as it would raise its usability.

An approach to solve the issues regarding BPMN was the creation of an extention of BPMN, BPMN-R, which includes expanded elements and notation for these purposes. While providing value, the new extension is however not less time consuming, which is an issue in RPA implementations. New elements also result in additional extra time to learn how to use the new elements although it is not complex if one already possess knowledge of BPMN. In future work, other modeling languages could be tested to see if they are better suited for RPA purposes. BPMN-R with different detail levels could also be tried out to see if that changes its usefulness in this context.

5.4 Implications from Advances in Artificial Intelligence

In Section 2.1 the type of RPA that is investigated in this study was described. While this established the technological boundaries for this particular study, the RPA technology is developing fast and in a few years the type of RPA that was investigated in this study might be obsolete. The primary innovation that is anticipated to transform the technology is the development of Artificial Intelligence (AI) within RPA. AI has already been introduced to RPA but will have a greater impact when it develops further in the coming years. If the technology changes, the framework also needs to adapt to these changes. How the different categories need to adapt to the rise of AI within RPA is discussed below.

Risk Level: While the category will remain, since risk will always play an important part in any project, the elements within will change. AI will allow more complex processes to be automated and if the RPA technology reach wider acceptance, more essential processes will be allowed to be automated. What will replace these factors to determine risk in the future remains unclear. There is also the question as to what type of processes are desirable for automation with AI. While automation using strictly rule based RPA is deterministic as the RPA only does what it is programmed to do, adding more machine learning and cognitive elements might lead to situations where the automation does unexpected or even unwanted things, increasing the need to consider the risks involved.

Business Value: The current business values will probably stay rather intact. Even if the way of automating is updated, the values that can be achieved with the automation should remain. Although there might be added values that has not been regarded with the current technology. However, the focus between the categories might differ. For instance, if there is a reliance on machine learning there might be an increased focus on transaction volume so that there is enough data for the AI to improve.

Process Model: A process model can still be used to gain a better process understanding. AI however adds capabilities to RPA that has not been possible with the current technology. Therefore, there might be other factors that are important to illustrate in the model which are not focused, or possible, today. A possible factor could be the complexity of a decision, which shows the cognitive level of the robot that is required. Another factor could be to show if the robot has access to enough data, enabling it for machine learning.

There is also a possibility that a robot can analyze and use a process model as input and convert it to the actual automation. This would require a higher complexity for the model but also reduce the effort for implementing the robot.

Mandatory Criteria: This category will probably see the biggest change. Digital data will still be critical but with smarter robots, the structure of the data will not be as important. The need for simple rules and few exceptions will disappear as the robots will have the capabilities of taking decisions that occur, although new criteria that differentiate between different kinds of decisions might be added. Repetitiveness will probably still be important in order to gain the benefits from the automation over time, the same reasoning applies to stability as well.

Optional criteria: The criteria in this category will probably remain. However, new criteria will most likely add on since the technology will have capabilities that can help to identify new areas where RPA can excel.

5.5 Threats to Validity

To determine how strong the claims of this study are and address any limitations of the conclusions and the generalizability of these, this section will go through different threats to validity. These threats have been categorized as threats to internal, external and construct validity.

5.5.1 Internal Validity

Internal validity focuses on the casual relations and determining whether or not these can be supported or if there are other factors that could have an impact [39]. Something which had an impact on the conclusions drawn in this study was the selection of processes, for which the methods, both existing and the newly designed RPA Suitability Framework, were applied. In the first round of interviews the specific processes that were sought were either considered by the interviewee to be most time consuming or most suitable for RPA. During the second round of interviews, this was changed to include the four areas of business value that were included in the RPA Suitability Framework. This was done to gather a larger number of candidate processes out of which a few could be selected to be modeled and used to test the methods. This was done as it was not easy to ask for processes without any criteria and the initial choice of asking for the most time consuming process did no longer make sense when the RPA Suitability Framework covered four different areas of business value, including time consuming. However there is a risk of having done it this way that the processes collected fit well with the RPA Suitability Framework due to being selected based on the matching areas of business value. This would only be true when it comes to the areas of business value as the rest of the RPA Suitability Framework was not used. In fact, it is more correct to say that the areas of business value that were identified by reviewing and consolidating other methods were used to help the interviewee come up with potential processes.

One downside of doing this selection the way it was done is that it makes it harder to discover new areas of business value through the interviews as the processes that are found match the given areas of business value. This was however not the main point of the interviews and the sources for the business values listed in the RPA Suitability Framework all come from existing methods.

Another point is that since BPMN, and later BPMN-R, was used to communicate the understanding of business processes, knowledge of BPMN could be a limiting factor, both on the side of the researchers and interview subjects. As mentioned in Section 3.4, the researchers used online resources to increase their knowledge and understanding of BPMN beforehand, which helped reduce this threat to validity. When it came to using process models for communication these were thoroughly explained when presented during the validation meetings to make sure everyone had the same understanding of the model. This proved helpful as the interviewees could intervene and comment on parts that had been misunderstood by the researchers, no matter their experience with BPMN.

5.5.2 Construct Validity

The construct validity focuses on the measures being used and if they reflect what is intended [39]. A key point here is about how the RPA Suitability Framework was evaluated. The chosen three ways, comparing the recommended processes, comparing the criteria and the evaluation workshop all help with assessing the value of the new framework but might not capture all relevant aspects. Another way to evaluate it, which would strengthen the evaluation, would be to compare the outcome, that is how well an RPA implementation went, of using the RPA Suitability Framework compared to other methods. That would allow to see how the actual implementation is effected by the choice of selection method. However, this would require a substantial amount of time and willingness from a partner company to perform, as it would be best to evaluate it in an actual setting.

In section 5.3 it was discussed why criteria have not been consolidated yet. A possible explanation is that commercial actors benefit from being able to present exclusive solutions. If this is the case, there is also a possibility that existing methods from commercial sources are purposely pictured in a specific way to attract possible customers. But a method presented with this purpose might not be the optimal method. There is also a possibility that sources claim that RPA can achieve more than what it is actually capable of. This threat has been mitigated by looking at a lot of different sources but it still can not be claimed that it is not a threat.

5.5.3 External Validity

External validity relates to how the findings in the study can be generalized to other contexts [39]. As this study was conducted solely at one company and the evaluation of the RPA Suitability Framework was held solely with representatives of one company, it is hard to say if the same conclusions can be drawn in other cases. For example, during the evaluation workshop, described in Section 4.4.5, the participants said that the criteria *standardized process* had a different meaning due to the word *standardized* having a very specific meaning at the company. Other aspects of this study might also be especially tailored to the needs and requirements of the partner company. In order to recommend the RPA Suitability Framework for more general use, it should be applied in other contexts to increase the generalizability.

Another aspect that is relevant to consider is the impact that the researchers had on the study. While it is practically impossible to remain entirely unbiased, it is important to have a look at how any potential bias might have affected the study. One aspect that was briefly discussed in Section 4.4.5 was that the consideration of what to do with employees who's processes were automated might have received higher attention due to the fact that this study was performed in Sweden at a Swedish company and conducted by two Swedish students. If the study would have been conducted in a country were employment laws are different this might have received less attention as it becomes less of an issue. There is also the question as to how the interpretation and consolidation of criteria was done, described in Section 3.3. To reduce the bias from the individual researchers this was done individually and then merged, but this does not affect bias that might be present for both individuals due to similar background and nationality. Therefore it would be good to see a similar study done in another context to see if a similar outcome would be found.

6 Conclusions

In this thesis 23 existing methods for selecting processes to automate using RPA have been reviewed. This revealed a number of issues described in Section 4.2. The study also included how BPMN could be used to help in assessing which processes that should be automated. Like with the existing selection methods, a couple of issues with using BPMN for this purpose were discovered.

To handle these issues a new methodology was designed, called the RPA Suitability Framework. The framework was built upon the existing selection methods but classified criteria into different categories that handled different aspects important to consider. This new framework also included an extension of the BPMN language called BPMN-R which added functionality which helped in the assessment of processes.

The RPA Suitability Framework was applied to processes at the partner company, similar to how the existing methods were used, and then compared against the previous methods to see if it did in fact prove to be an improvement over these. An evaluation workshop was also held with the partner company to evaluate this new method. The evaluation showed that it was an improvement in many ways over existing methods. However, since the context in which it was used was limited, the generalizability was also limited and further studies using the RPA Suitability Framework would be needed before it can be recommended for general use.

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Appendix A
Original List of Criteria

Original list of criteria

Source	Original Criteria/Guideline	ID Original
Willcocks, Lacity & Craig (2015)	Future evolution would seem to begin with RPA which is optimally used with high volume, standardized, rules-based mature stable processes where costs are clear and business value well understood	A1
Willcocks, Lacity & Craig (2015) (Xchanging)	The RPA software seemed most suitable where degree of process standardization, transaction volumes, rules-based process and process maturity were all high.	A2
Willcocks, Lacity & Craig (2015) (Xchanging)	RPA fitted more with high volume, low complex work	A3
Willcocks, Lacity & Craig (2015) (Xchanging)	High volume, repetitive tasks are better performed by robots, not least due to removal of human error.	A4
Lacity & Wilcocks (2016)	Companies are achieving productivity gains by using software robots to perform routine, rules-based service processes	A5
Lacity & Wilcocks (2016)	Software tools and platforms that can automate rules-based processes that involve structured data and deterministic outcomes	A6
Asatiani & Penttinen (2016)	One should evaluate whether the task is routine or non-routine and whether it requires the use of manual or cognitive affordances	A7
Asatiani & Penttinen (2016)	Determine whether one can precisely write down all the steps of the process, taking into account all possible events and outcomes along the way	A8
Asatiani & Penttinen (2016)	High volume of transactions	A9
Asatiani & Penttinen (2016)	Need to access multiple systems	A10
Asatiani & Penttinen (2016)	Stable environment	A11
Asatiani & Penttinen (2016)	Easy decomposition into unambiguous rules	A12
Asatiani & Penttinen (2016)	Proneness to human error	A13
Asatiani & Penttinen (2016)	Limited need for exception handling	A14
Asatiani & Penttinen (2016)	Clear understanding of the current manual costs	A15
Lacity, Willcocks & Craig (2015)	Volume of transactions: High	A16
Lacity, Willcocks & Craig (2015)	Degree of process standardization: High	A17
Lacity, Willcocks & Craig (2015)	Degree to which process is rules-based: High	A18
Lacity, Willcocks & Craig (2015)	Degree of process maturity: High	A19
Lacity, Willcocks & Craig (2015)	One of the advantages of RPA is that it is highly interoperable and can readily run on any platform	A20
Accenture (NA)	The process should be rule based and not depend on human judgement	A21
Accenture (NA)	The process should be initiated by a digital trigger and be supported by digital data	A22
Accenture (NA)	The process should be functioning and stable	A23
Accenture (NA)	The bigger the volume of executions of the process the better	A24
Accenture (NA)	For a Proof of Concept project, it is key that the process leverages the key systems of the company	A25
Deloitte (2017)	Manual interaction with computer interface	A26
Deloitte (2017)	Largely rules based	A27
Deloitte (2017)	Consume a significant amount of time	A28
Deloitte (2017)	Performed at frequent intervals	A29
Deloitte (2017)	Potential for significant reduction in effort	A30
Deloitte (2017)	Low risk	A31
Deloitte UK (NA)	Rules based	A32
Deloitte UK (NA)	Prone to error	A33
Deloitte UK (NA)	Involves digital data	A34
Deloitte UK (NA)	Repetitive	A35
Deloitte UK (NA)	Time critical and seasonal	A36
Cutter Consortium (2017)	Stable	A37
Cutter Consortium (2017)	Repetitive in nature	A38
Cutter Consortium (2017)	Structured in nature	A39
Cutter Consortium (2017)	Processes that DON'T depend on government guidelines and have high change rates	A40
Kryon Systems (2015)	The first rule of thumb is that a process must be rules-based and definable to be automated.	A41
Kryon Systems (2015)	These types of processes are most often data-driven and lend themselves to tedious and repetitive tasks	A42

Kryon Systems (2015)	The Human Factor - Processes that are consuming too much of your worker's time or using too many dedicated human resources. By automating mundane, repetitive, administrative tasks you can....	A43
Kryon Systems (2015)	Complexity - Complex processes that have critical functions in your company's day-to-day business operations have more to achieve with RPA and usually result in greater gains and ROI.	A44
Kryon Systems (2015)	Stability - A process that changes frequently or has significant unplanned change is a poor candidate for automation.	A45
Sutherland (2016)	Rules-based transactions	A46
Sutherland (2016)	Electronic Data In → Electronic Data Out	A47
Sutherland (2016)	Multiple systems	A48
Sutherland (2016)	Workflow enabled: Processes that can be broken down into a series of orchestrated, repeatable activities are often prime for RPA	A49
Sutherland (2016)	High volume	A50
Sutherland (2016)	Involve searching, collating or updating information	A51
Sutherland (2016)	The best return on investment comes from the more simple processes where the cost of development is lower	A52
Cap Gemini (2016)	Processes that require access to multiple systems	A53
Cap Gemini (2016)	Processes prone to human error Processes	A54
Cap Gemini (2016)	Processes that can be broken down into unambiguous rules	A55
Cap Gemini (2016)	Process once started, need limited human intervention	A56
Cap Gemini (2016)	Processes that require limited exception handling	A57
Cap Gemini (2016)	Processes executed frequently, in large numbers or with significant peaks in workload Process	A58
Cap Gemini (2016)	Process has no strategic fit	A59
PWC (2017)	Across many (stable) IT systems	A60
PWC (2017)	High volume and handling time	A61
PWC (2017)	Fixed procedures must be followed	A62
PWC (2017)	Standardised and mature	A63
PWC (2017)	Manual and rule-based	A64
PWC (2017)	Often processing errors	A65
EY (2015)	Actions are consistent, with repeated steps	A66
EY (2015)	Template-driven, with data entered in specific fields in a repetitive way	A67
EY (2015)	Rules-based to allow decision flows to alter dynamically	A68
TCS (2017)	Repetitive tasks, which robots can perform better than humans	A69
TCS (2017)	For example, copying and moving data from one system to another	A70
TCS (2017)	Tasks that have to be performed 24*7	A71
TCS (2017)	Error prone or have high re-work rate	A72
HfS (2013)	Need to access multiple systems	A73
HfS (2013)	Prone to errors or rework	A74
HfS (2013)	Easy decomposition into unambiguous rules	A75
HfS (2013)	Limited need for human intervention	A76
HfS (2013)	Limited need for exception handing.	A77
HfS (2013)	Clear understanding of the current manual costs	A78
HfS (2013)	The transaction volumes and/or the value of the transactions are high	A79
UiPath (2014)	The process requires access to multiple systems	A80
UiPath (2014)	The process is prone to human error	A81
UiPath (2014)	The process can be broken into unambiguous rules	A82
UiPath (2014)	The process, once started, needs limited human intervention	A83
UiPath (2014)	The process should require limited exception handling	A84
Genpact (2017)	Labor intensive/ high number of FTEs	A85
Genpact (2017)	Basic procedure with simple rules & logic	A86
Genpact (2017)	Standardized/ structured data	A87
Genpact (2017)	High fluctuation in demand	A88
Genpact (2017)	Bottlenecks causing high cycle times	A89
Ayehu (2015)	Processes that already do not require much human intervention	A90

Ayehu (2015)	Processes that tend to be more prone to human error	A91
Ayehu (2015)	Processes that require multiple systems to work in sync	A92
Ayehu (2015)	Processes that have clear-cut rules	A93
Ayehu (2015)	Processes that require limited exceptions	A94
Virtual Operations (2014)	Structured	A95
Virtual Operations (2014)	Rules-based	A96
Virtual Operations (2014)	Repeatable	A97
Virtual Operations (2014)	Computer based tasks	A98
Virtual Operations (2014)	Searching, collating or updating information	A99
Virtual Operations (2014)	Accessing one or more systems to complete a process	A100
Virtual Operations (2014)	Performing simple or complex decisions and algorithms	A101
Virtual Operations (2014)	Highly regulated activities (banking, financial services, healthcare)	A102
Virtual Operations (2014)	Fluctuating volumes (seasonality, new client transitions, production rollouts)	A103
Virtual Operations (2014)	Facility or workforce transitions Virtual	A104
IRPAAI (NA)	Repetitive, Redundant and Risky	A105
Infosys (2017)	Manual processes	A106
Infosys (2017)	High-volume work	A107
Infosys (2017)	Repetitive tasks	A108
Infosys (2017)	Rule-based decisions with minimal deviations	A109
Infosys (2017)	Probability of error	A110
Minit (2018)	Ones with strategic value	A111
Minit (2018)	The actions are consistent, with the same step being performed repeatedly. Typically, repetitive processes are also susceptible to human error.	A112
Minit (2018)	The process can be broken into unambiguous rules that apply to the majority of transactions.	A113
Minit (2018)	It is template driven, with data being entered into specific fields in a repetitive manner	A114
Minit (2018)	It is rules-based, to allow decision flows to alter dynamically	A115
Minit (2018)	The process, once started, needs limited human intervention. Decision-heavy processes can also be partially automated.	A116
Minit (2018)	The process should require only limited exception handling.	A117
Willcocks, Lacity & Craig (2015)	RPA software is ideally suited to replace humans for so called “swivel chair” processes; processes where humans take inputs from one set of systems (for example email), process those inputs using rules, and then enter the outputs into systems of record (for example Enterprise Resource Planning (ERP) systems)	A118

Appendix B
Consolidated List of Criteria

List of criteria that has been consolidated from the original list.

ID Original	Consolidated Criteria	ID Consolidated
A1	Clear business value	B1
A1	Clear costs	B2
A15	Clear costs	B2
A78	Clear costs	B2
A44	Complex	B3
A98	Computer based	B4
A89	Contains bottlenecks	B5
A44	Critical in day-to-day operations	B6
A42	Data driven	B7
A41	Definable	B8
A8	Definable	B8
A6	Determenistic outcome	B9
A22	Digital data	B10
A34	Digital data	B10
A47	Digital data	B10
A22	Digital trigger	B11
A110	Error prone	B12
A112	Error prone	B12
A13	Error prone	B12
A33	Error prone	B12
A54	Error prone	B12
A65	Error prone	B12
A72	Error prone	B12
A74	Error prone	B12
A81	Error prone	B12
A91	Error prone	B12
A109	Few exceptions	B13
A117	Few exceptions	B13
A14	Few exceptions	B13
A57	Few exceptions	B13
A77	Few exceptions	B13
A84	Few exceptions	B13
A94	Few exceptions	B13
A62	Fixed procedures	B14
A103	Fluctuating demand	B15
A36	Fluctuating demand	B15
A58	Fluctuating demand	B15
A88	Fluctuating demand	B15
A105	High risk	B16
A107	High transaction volume	B17
A24	High transaction volume	B17
A29	High transaction volume	B17
A50	High transaction volume	B17
A58	High transaction volume	B17
A61	High transaction volume	B17
A9	High transaction volume	B17
A1	High transaction volume	B17
A16	High transaction volume	B17
A2	High transaction volume	B17
A79	High transaction volumes or high value of transactions	B18

A102	Highly regulated	B19
A51	Involve searching, collating or updating information	B20
A99	Involve searching, collating or updating information	B20
A116	Limited human intervention	B21
A21	Limited human intervention	B21
A56	Limited human intervention	B21
A76	Limited human intervention	B21
A83	Limited human intervention	B21
A90	Limited human intervention	B21
A7	Low cognitive requirements	B22
A3	Low complexity	B23
A31	Low risk	B24
A106	Manual	B25
A64	Manual	B25
A26	Manual interaction with computer interface	B26
A1	Multiple systems	B27
A10	Multiple systems	B27
A100	Multiple systems	B27
A118	Multiple systems	B27
A20	Multiple systems	B27
A48	Multiple systems	B27
A53	Multiple systems	B27
A60	Multiple systems	B27
A70	Multiple systems	B27
A73	Multiple systems	B27
A80	Multiple systems	B27
A92	Multiple systems	B27
A40	No change due to regulations	B28
A59	No strategic fit	B29
A71	Performed at all hours	B30
A101	Performing simple or complex decisions and algorithms	B31
A30	Potential for savings	B32
A104	Redeployable personel	B33
A105	Redundant	B34
A105	Repetitive	B35
A108	Repetitive	B35
A112	Repetitive	B35
A35	Repetitive	B35
A4	Repetitive	B35
A42	Repetitive	B35
A66	Repetitive	B35
A69	Repetitive	B35
A97	Repetitive	B35
A38	Repetitve	B35
A5	Routine	B36
A7	Routine	B36
A1	Rules based	B37
A109	Rules based	B37
A113	Rules based	B37
A12	Rules based	B37
A18	Rules based	B37

A2	Rules based	B37
A21	Rules based	B37
A27	Rules based	B37
A32	Rules based	B37
A41	Rules based	B37
A46	Rules based	B37
A5	Rules based	B37
A55	Rules based	B37
A64	Rules based	B37
A68	Rules based	B37
A75	Rules based	B37
A82	Rules based	B37
A86	Rules based	B37
A93	Rules based	B37
A96	Rules based	B37
A52	Simple	B38
A86	Simple	B38
A1	Stable	B39
A19	Stable	B39
A2	Stable	B39
A23	Stable	B39
A37	Stable	B39
A45	Stable	B39
A63	Stable	B39
A11	Stable underlying systems	B40
A60	Stable underlying systems	B40
A1	Standardized	B41
A17	Standardized	B41
A2	Standardized	B41
A63	Standardized	B41
A114	Standardized data input	B42
A67	Standardized data input	B42
A111	Strategic value	B43
A39	Structured	B44
A67	Structured	B44
A95	Structured	B44
A6	Structured data	B45
A87	Structured data	B45
A49	Structured sequence of sub-processes	B46
A42	Tedious	B47
A28	Time consuming	B48
A43	Time consuming	B48
A61	Time consuming	B48
A85	Time consuming	B48
A36	Time critical	B49

Appendix C

New Method Criteria

New method criteria with tracing from consolidated criteria. Many criteria have been removed. Some criteria have turned into a category of criteria in the new method.

	ID Consolidated	New Method Criteria	ID New Method	Comment
Clear business value	B1	-	-	Category: Business value
Clear costs	B2	-	-	Removed
Complex	B3	High complexity	C1	
Computer based	B4	-	-	Removed
Contains bottlenecks	B5	Contains bottlenecks	C2	
Critical in day-to-day operations	B6	Essential process	C3	
Data driven	B7	Rules based	C4	
Definable	B8	-	-	Removed
Determenistic outcome	B9	Rules based	C4	
Digital data	B10	Digital and structured data	C5	
Digital trigger	B11	Digital trigger	C6	
Error prone	B12	Error prone	C6	
Few exceptions	B13	Few exceptions	C7	
Fixed procedures	B14	Standardized process	C8	
Fluctuating demand	B15	Fluctuating demand	C9	
High risk	B16	No fault tolerence	C10	
High transaction volume	B17	High transaction volume	C11	
High transaction volumes or high value of transactions	B18	High transaction volume	C11	
Highly regulated	B19	Regulatory	C12	
Involve searching, collating or updating information	B20	-	-	Removed
Limited human intervention	B21	Rules based	C4	
Low cognitive requirements	B22	Rules based	C4	
Low complexity	B23	Low complexity	C13	
Low risk	B24	-	-	Category: Risk level
Manual	B25	-	-	Removed
Manual interaction with computer interface	B26	-	-	Removed
Multiple systems	B27	Multiple systems	C14	
No change due to regulations	B28	Stable process and environment	C15	
No strategic fit	B29	Non essential process	C16	
Performed at all hours	B30	24/7 potential	C17	
Performing simple or complex decisions and algorithms	B31	-	-	Removed
Potential for savings	B32	-	-	Removed
Redeployable personnel	B33	Redeployable personnel	C18	
Redundant	B34	Redundant checks	C19	
Repetitive	B35	Repetetive	C20	
Routine	B36	Repetetive	C20	
Rules based	B37	Rules based	C4	
Simple	B38	Low complexity	C13	
Stable	B39	Stable process and environment	C15	
Stable underlying systems	B40	Stable process and environment	C15	
Standardised data input	B41	Standardized process	C8	
Standardized	B42	Standardized process	C8	
Strategic value	B43	Essential process	C3	
Structured	B44	-	-	Removed
Structured data	B45	Digital and structured data	C5	
Structured sequence of sub-processes	B46	-	-	Removed
Tedious	B47	Tedious	C21	
Time consuming	B48	Time savings	C22	
Time critical	B49	Time critical	C23	

Appendix D

Consolidated Criteria per Source

Source	Criteria
Willcocks (2015)	Clear business value
	Clear costs
	Stable
	High transaction volume
	Multiple systems
	Rules based
	Standardized
Willcocks (Xchanging) (2015)	Standardized
	High transaction volume
	Rules based
	Stable
	Low complexity
	Repetitive
Lacity, Wilcocks (2016)	Rules based
	Routine
	Structured data
	Determenistic outcome
Asatiani, Penttinen (2016)	Routine
	Low cognitive requirements
	Definable
	High transaction volume
	Multiple systems
	Stable underlying systems
	Rules based
	Error prone
	Few exceptions
	Clear costs
Lacity (2015)	Multiple systems
	High transaction volume
	Standardized
	Rules based
	Stable
Accenture	Rules based
	Limited human intervention
	Digital data
	Digital trigger
	Stable
	High transaction volume
Deloitte (2017)	Manual interaction with computer interface
	Rules based
	Time consuming
	High transaction volume
	Low risk
	Potential for savings
Deloitte UK	Rules based
	Error prone
	Digital data
	Repetitive
	Time critical
	Fluctuating demand
Cutter Consortium (2017)	Structured
	Repetitive
	Stable
	No change due to regulations
Kryon Systems (2015)	Rules based
	Definable
	Data driven
	Repetitive
	Time consuming
	Tedious
	Complex
	Critical in day-to-day operations
	Stable
Sutherland (2016)	Rules based
	Digital data
	Multiple systems
	Structured sequence of sub-processes
	High transaction volume
	Involve searching, collating or updating information
	Simple
Cap Gemini (2016)	Multiple systems
	Error prone
	Rules based
	Limited human intervention
	Few exceptions
	High transaction volume
	Fluctuating demand
	No strategic fit

PWC (2017)	Multiple systems
	Stable underlying systems
	High transaction volume
	Time consuming
	Fixed procedures
	Rules based
	Stable
	Standardized
	Manual
	Error prone
EY (2015)	Repetitive
	Structured
	Rules based
	Standardised data input
TCS (2017)	Repetitive
	Error prone
	Performed at all hours
	Multiple systems
HfS (2013)	Multiple systems
	Error prone
	Rules based
	Limited human intervention
	Few exceptions
	Clear costs
	High transaction volumes or high value of transactions
UiPath (2014)	Multiple systems
	Error prone
	Rules based
	Limited human intervention
	Few exceptions
Genpact (2017)	Time consuming
	Simple
	Rules based
	Structured data
	Fluctuating demand
	Contains bottlenecks
Ayehu (2015)	Limited human intervention
	Error prone
	Multiple systems
	Rules based
	Few exceptions
Virtual Operations (2014)	Structured
	Rules based
	Repetitive
	Computer based
	Involve searching, collating or updating information
	Multiple systems
	Performing simple or complex decisions and algorithms
	Highly regulated
	Fluctuating demand
	Redeployable personel
IRPAAI	Repetitive
	Redundant
	High risk
Infosys (2017)	Manual
	High transaction volume
	Repetitive
	Rules based
	Few exceptions
	Error prone
Minit (2018)	Strategic value
	Repetitive
	Error prone
	Rules based
	Standardised data input
	Limited human intervention
	Few exceptions

Appendix E

Criteria Clarification

Criteria	Clarification
Clear business value	The value that can be achieved by automating the process is clear.
Clear costs	The cost for automating the process is clear.
Complex	A complex process can for instance be long, hard to define and include multiple systems, stakeholders, users, log-ins etc.
Computer based	The process is carried out using computers.
Contains bottlenecks	The process includes one ore more events that slows down the flow for the entire process.
Critical in day-to-day operations	The process is essential for the business to maintain its normal operations.
Data driven	Decisions in the process are based upon the data that enters the process.
Definable	The process can easily be captured and described.
Determenistic outcome	The outcome of the process is not influenced by any random elements.
Digital data	All inputs are in digital form and the data is stored digitally.
Digital trigger	The process is initiated digitally and initiating does not require human interference.
Error prone	It is normal for the process to produce errors.
Few exceptions	The process seldom deviates from its' normal flow.
Fixed procedures	The process is structured and performed in a fixed manner.
Fluctuating demand	The process volume has peaks and dips. E.g. seasonal variation.
High risk	For this process it is critical that there are no errors as the risks involved are high
High transaction volume	The process is performed often.
High transaction volumes or high value of transactions	This criteria also allows processes that are not necessarily performed often but have higher value when they are performed.
Highly regulated	The process is bound by regulations causing complience to be imortant.
Involve searching, collating or updating information	Criteria that express specific tasks that should be included in the process.
Limited human intervention	The process has few points where human decision making is needed.
Low cognitive requirements	The process is simple and does not require high levels of analysis or reasoning.
Low complexity	The process is comprehensible, not to long and does not include many systems, stakeholders, users, log-ins etc.
Low risk	The risk with automating the process is low
Manual	The process is not automated
Manual interaction with computer interface	There is a computer interface and a person performs the process by interacting with it...
Multiple systems	Different systems are used durng the process
No government restrictions	The process has no restrictions or is not prone to change due to these.
No strategic fit	The process is not strategically important.
Performed at all hours	The process can be performed at any given time of the day.
Performing simple or complex decisions and algorithms	Doing simple or difficult tasks...
Potential for savings	There is some value, in the form of cost reduction, to be gained from automating the process
Redeployable personnel	The personnel performing the process are possible to let go or assign other tasks.
Redundant	The process includes repeated steps that performs the same actions.
Repetitive	The process is performed many times in the same manner
Routine	After being performed many times, the steps of the process have become second nature
Rules based	The steps in the process depend on pre-set rules and does not include decisions that require human interference.
Simple	The process has low complexity
Stable	The process rarely changes.
Stable underlying systems	The systems used in the process rarely change.
Standardised data input	Data entering the process is always inserted in the same way.
Standardized	The process is performed the same way regardless of who performs it.
Strategic value	The process is of importance to the company.
Structured	The process flow is clear and can easily be defined.
Structured data	Data used in the process have the same properties each time the process is performed.
Structured sequence of sub-processes	The process flow can be divided into smaller sub-processes that are performed in an established order.
Tedious	Employees working with the process consider the tasks to be tedious.
Time consuming	The process takes a lot of time to perform, either due to high volume or due to the cycle time
Time critical	It is crucial that the process is performed either at a specific time or straight after the order to initiate the process.

Appendix F

Initial Analysis of Criteria

Criterion	Clarity	Ease of use	Significance
Clear business value	4	4	5
Clear costs	4	4	3
Complex	3	2	3
Computer based	5	5	1
Contains bottlenecks	5	4	3
Critical in day-to-day operations	4	4	3
Data driven	2	2	3
Definable	5	4	2
Determenistic outcome	4	2	3
Digital data	5	5	5
Digital trigger	4	5	3
Error prone	5	4	4
Few exceptions	5	4	5
Fixed procedures	3	3	3
Fluctuating demand	5	5	3
High risk	3	3	3
High transaction volume	5	4	4
High transaction volumes or high value of transactions	4	3	5
Highly regulated	5	4	2
Involve searching, collating or updating information	5	5	3
Limited human intervention	5	4	5
Low cognitive requirements	5	4	5
Low complexity	3	2	3
Low risk	3	3	3
Manual	5	5	1
Manual interaction with computer interface	5	5	1
Multiple systems	5	5	4
No change due to regulations	5	4	2
No strategic fit	1	1	2
Performed at all hours	5	5	4
Performing simple or complex decisions and algorithms	2	5	1
Potential for savings	4	4	3
Redeployable personel	4	4	4
Redundant	3	3	3
Repetitive	4	4	5
Routine	4	4	5
Rules based	5	4	5
Simple	4	3	3
Stable	5	4	5
Stable underlying systems	5	4	5
Standardized	4	3	4
Standardized data input	4	4	5
Strategic value	2	3	2
Structured	4	4	5
Structured data	5	5	5
Structured sequence of sub-processes	4	4	5
Tedious	5	5	4
Time consuming	4	4	4
Time critical	5	5	4

Appendix G
Interview Guide

G.1 Guide for First Round of Interviews

G.1.1 Guide for Heads of Departments

Intro:

- Introduction of the researchers
- Introduction of the problem: selecting processes to automate
- The goal of this interview is to get an overview of processes within the department. At a later stage, detailed descriptions of processes will be sought

Questions:

- Who are you?
- What is your title, and what does your department do?
- What do you know about RPA?
- How do you believe RPA can be used within your organization?
- How would you like RPA to be used?
- Now we will focus more about the processes within your department
- How are the processes within your department organized?
- What are some typical processes within your department or the different parts of your department?
- Who is the process owner of these processes?
- Have you any idea of which processes are suitable for RPA?
- Who are the experts on the processes? Is there anybody we can talk to to learn more about the processes?

G.1.2 Guide for Process Experts

Intro:

- Introduction of the researchers
- Introduction of the problem: selecting processes to automate
- The goal of this interview is to get a detailed description of two processes. One which we believe to be suitable for RPA and another, which is the process you work with the most.

Process questions:

- How does the process start? (Is it triggered digitally?) Who initiates the process?

- When does the process end? How does the end state look?
- Can you describe the steps of the process? Or can you show and walk through the process.
  - Which systems are used during the process?
  - Which steps in the process require you to make a decision?
  - What data is used and where does it come from? What amounts of data? How structured is the data?
  - How is the data input performed?
- How does the happy path of the process look (when nothing goes wrong)?
- How do the exceptions look? What needs to be added, fixed etc.
- Which step in the process is most difficult to perform? Why?
- Is it common with errors in the process? In what step?
- How long time does it take to do the process, which step is the most time consuming?
- How often do you perform the process?
- Are there any risks associated with the process? What happens if something goes wrong?
- Is it critical that the process is performed on time?
- Does the demand of the process vary much?
- Is this process changed often or has it been the same for a long time?

G.2 Guide for Second Round of Interviews

G.2.1 Guide for Heads of Departments

Intro:

- Introduction of the researchers
- Introduction of the problem: selecting processes to automate
- The goal of this interview is to get an overview of processes within the department. At a later stage, detailed descriptions of processes will be sought

Questions:

- Who are you?
- What is your title, and what does your department do?
- What do you know about RPA?
- Presentation of RPA Business Value Areas
  - Time savings
  - Quality & Accuracy
  - Error prone
  - High Accuracy Demand
- Employee satisfaction
- Flexibility
  - 24/7 potential
  - Time critical
  - Fluctuating demand
- Do you have any processes that fit into these categories?

- Who are the experts on the processes? Is there anybody we can talk to to learn more about the processes?

G.2.2 Guide for Process Experts

Intro:

- Introduction of the researchers
- Introduction of the problem: selecting processes to automate
- The goal of this interview is to get a detailed description of at least one process.
- Presentation of RPA Business Value Areas
  - Time savings
  - Quality & Accuracy
  - Error prone
  - High Accuracy Demand
- Employee satisfaction
- Flexibility
  - 24/7 potential
  - Time critical
  - Fluctuating demand

Process questions:

- Can you provide a brief description of the process and why it is performed?
- How does the process start? (Is it triggered digitally?) Who initiates the process?
- When does the process end? How does the end state look?
- Can you describe the steps of the process? Or can you show and walk through the process.
  - Which systems are used during the process?
  - Which steps in the process require you to make a decision?
  - What data is used and where does it come from? What amounts of data? How structured is the data?
  - How is the data input performed?
- How does the happy path of the process look (when nothing goes wrong)?
- How do the exceptions look? What needs to be added, fixed etc.
- Which step in the process is most difficult to perform? Why?
- Is it common with errors in the process? In what step?
- How long time does it take to do the process, which step is the most time consuming?
- How often do you perform the process?
- Are there any risks associated with the process? What happens if something goes wrong?
- Is it critical that the process is performed on time?
- Does the demand of the process vary much?
- Is this process changed often or has it been the same for a long time?
- Could this process be done during off-hours? Would there be any benefit to that?

Appendix H
Evaluation Workshop Questions

Questions for the evaluation workshop

- What do you think about the content? Is it relevant?
- What about the steps? Are they relevant? Does the order make sense?
- What do you think about process modelling? Is it useful and does it capture relevant aspects?
- Is there anything that the method is missing?
- Is the method easy to understand?

Figure H.1: The questions that were asked during the evaluation workshop.

Appendix I

BPMN Models

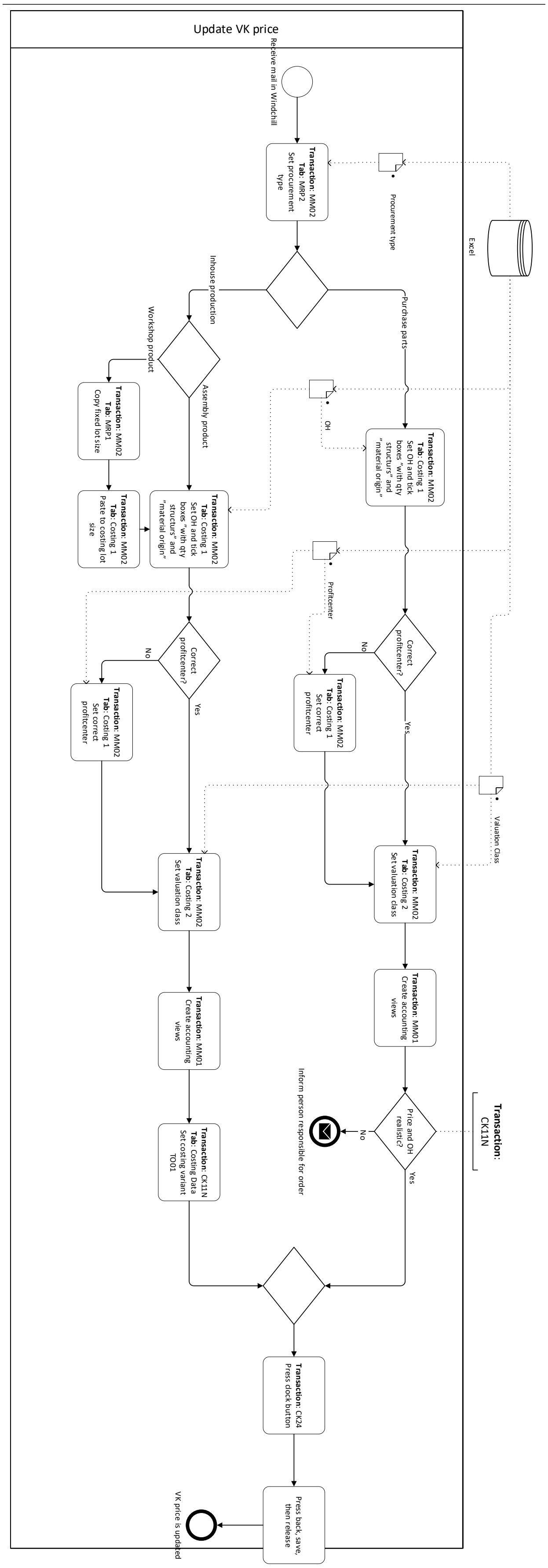

Figure I.1: BPMN model of process 1, price update.

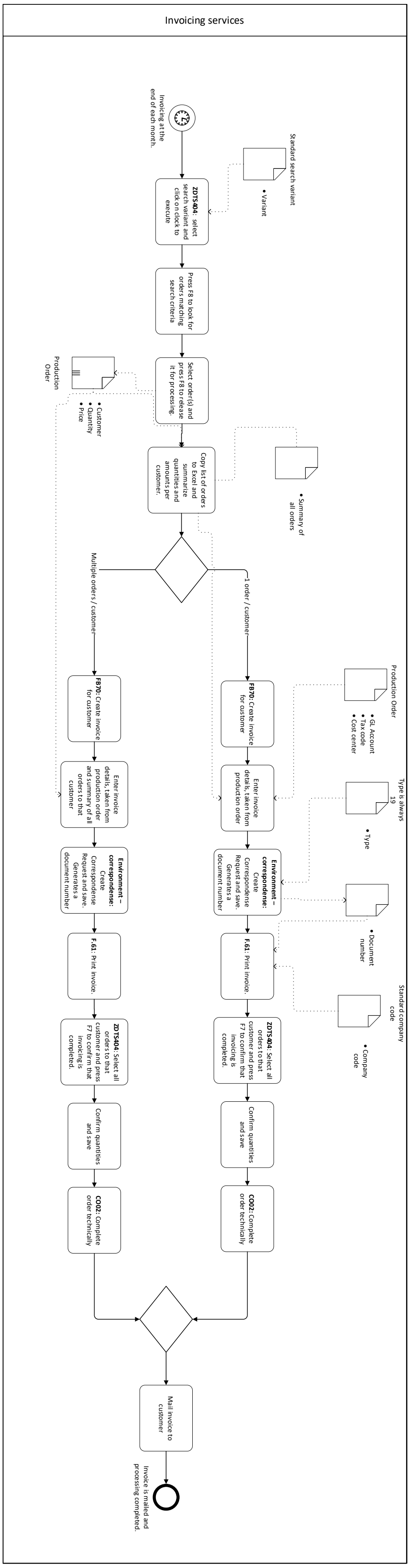

Figure I.2: BPMN model of process 2, invoicing services.

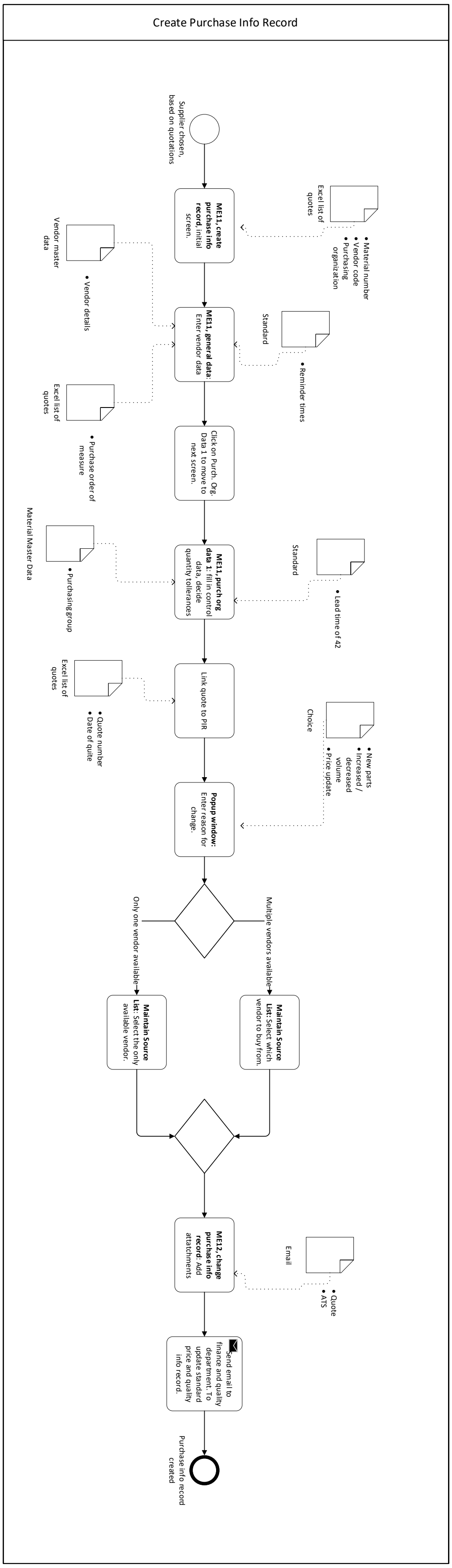

Figure I.3: BPMN model of process 3, creating a purchase info record.

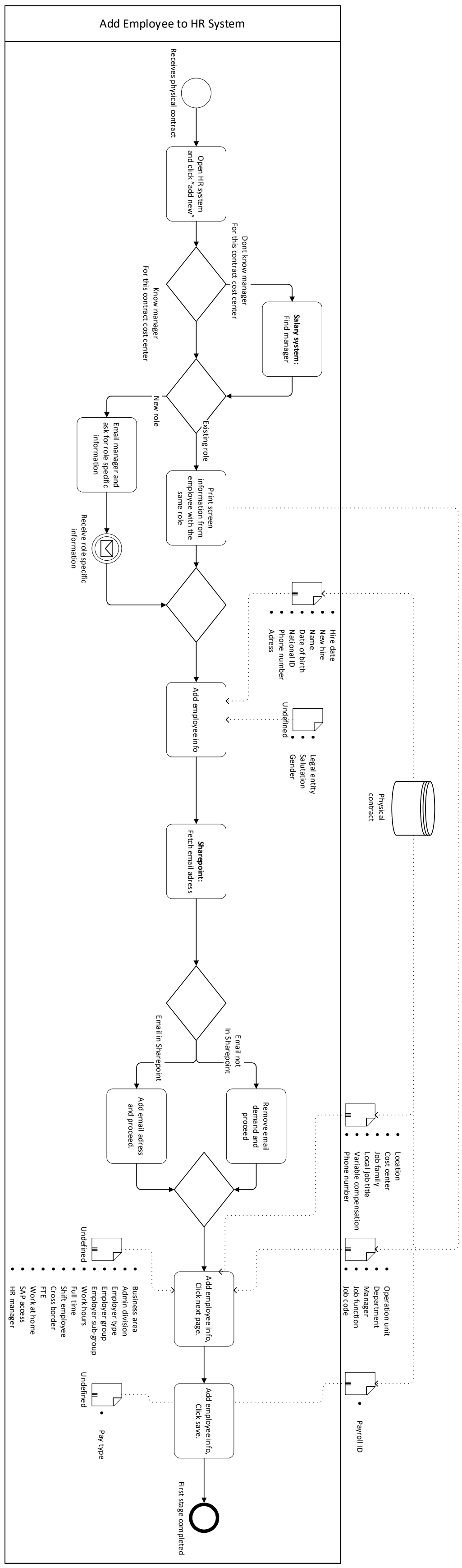

Figure I.4: BPMN model of process 4, adding an employee to HR system.

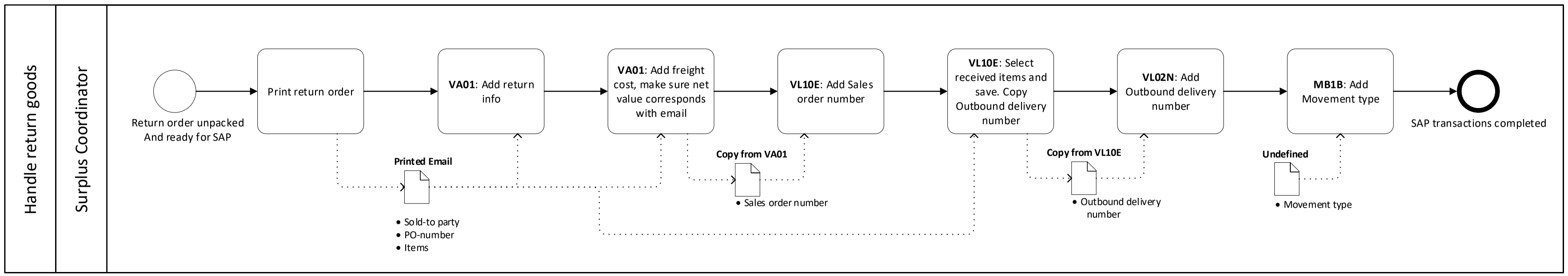

Figure I.5: BPMN model of process 5, handling of return goods.

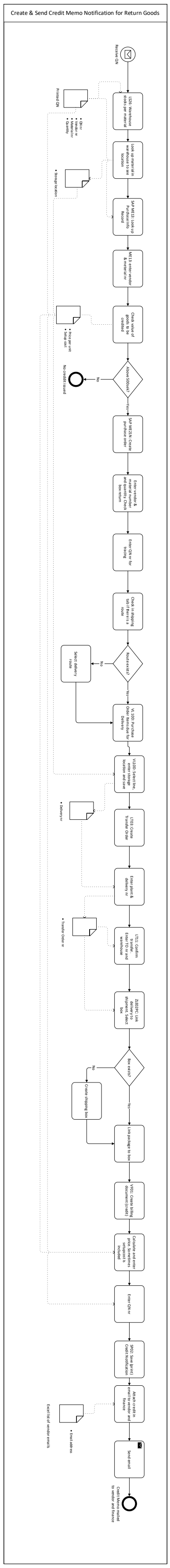

Figure I.6: BPMN model of process 6, creating and sending a credit memo notification.

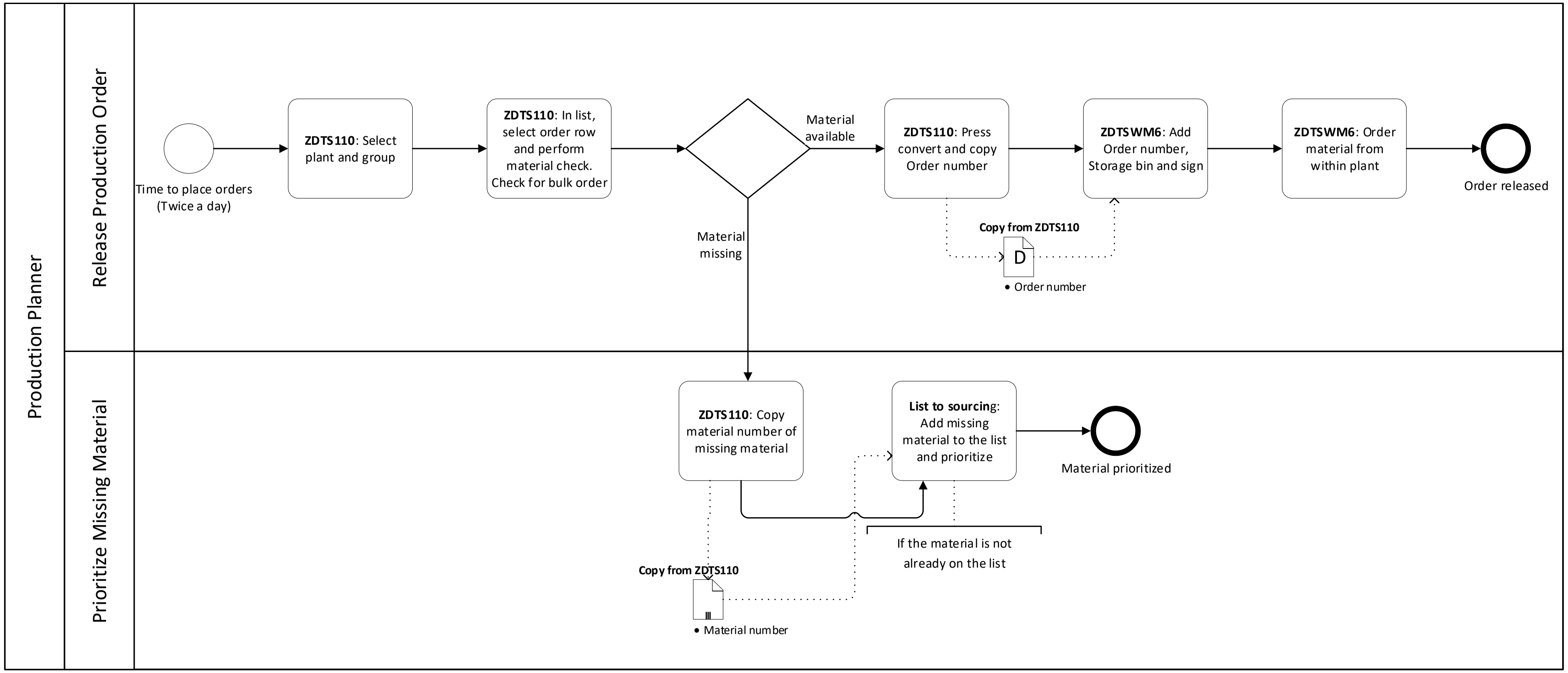

Figure I.7: BPMN model of process 7, releasing production orders.

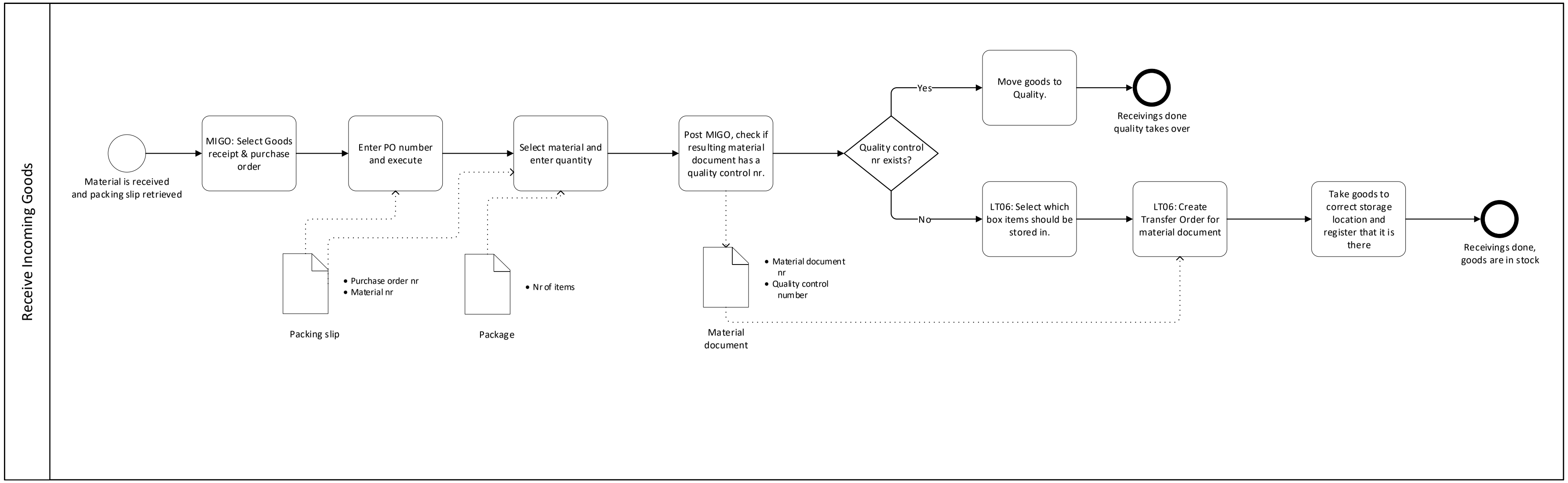

Figure I.8: BPMN model of process 8, receiving incoming goods.

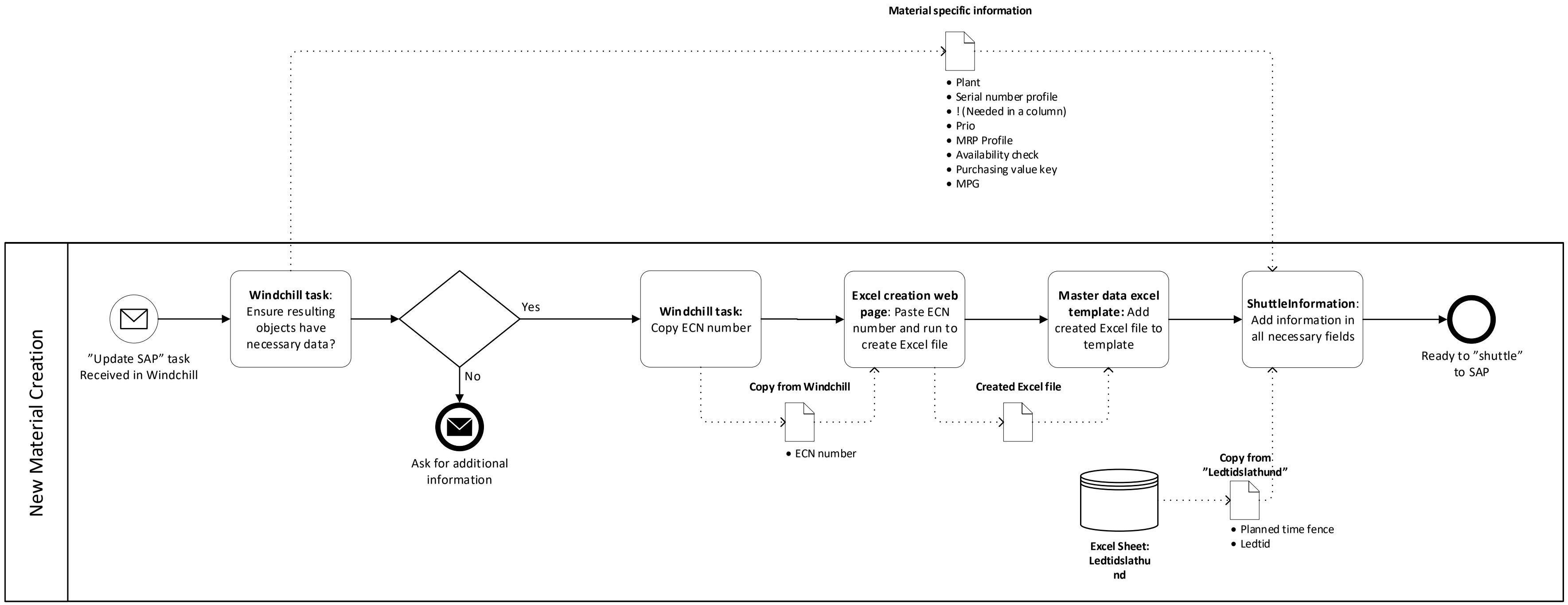

Figure I.9: BPMN model of process 9, new material creation.

Appendix J

BPMN-R Models

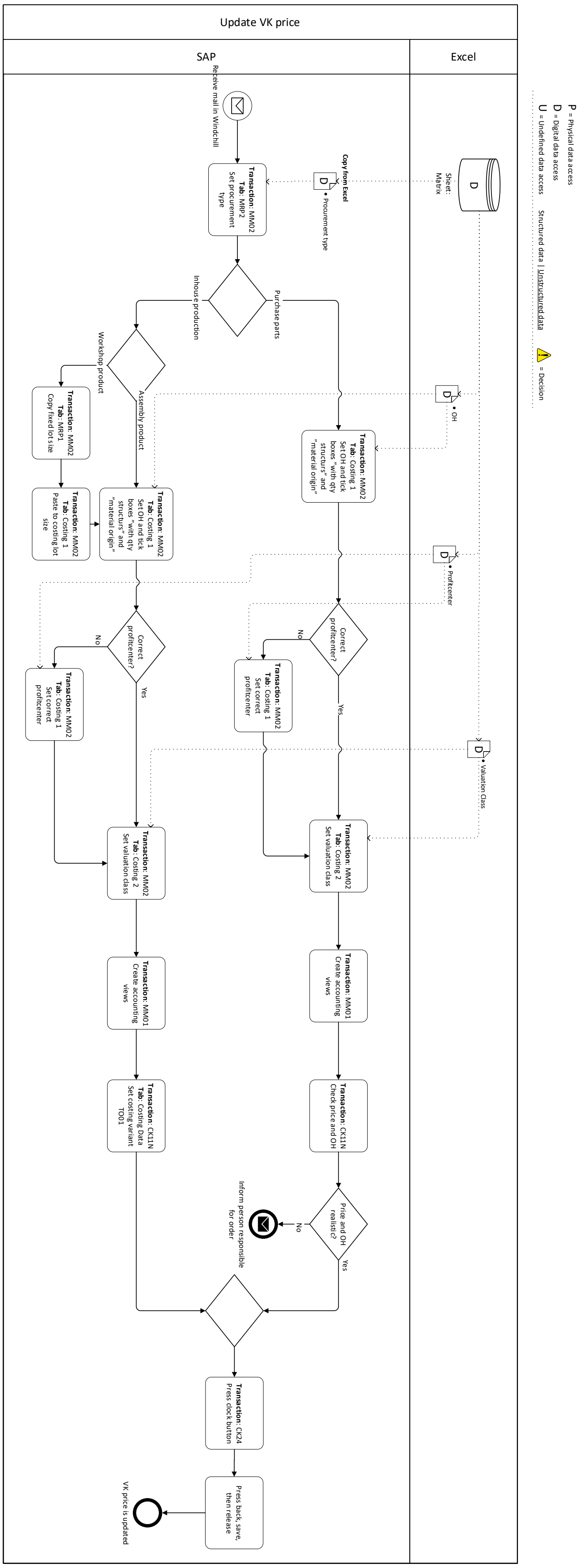

Figure J.1: BPMN-R model of process 1, price update.

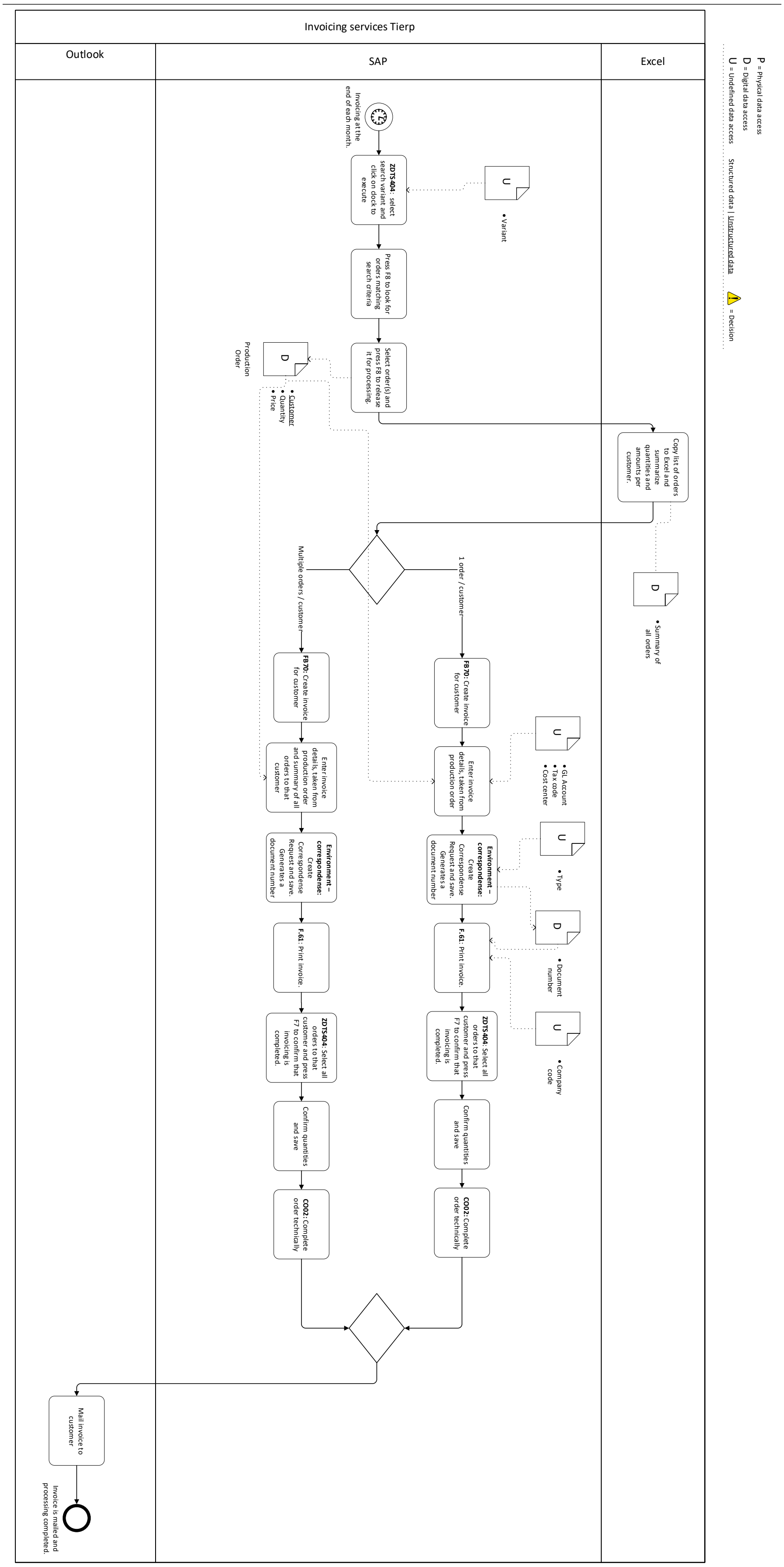

Figure J.2: BPMN-R model of process 2, invoicing services.

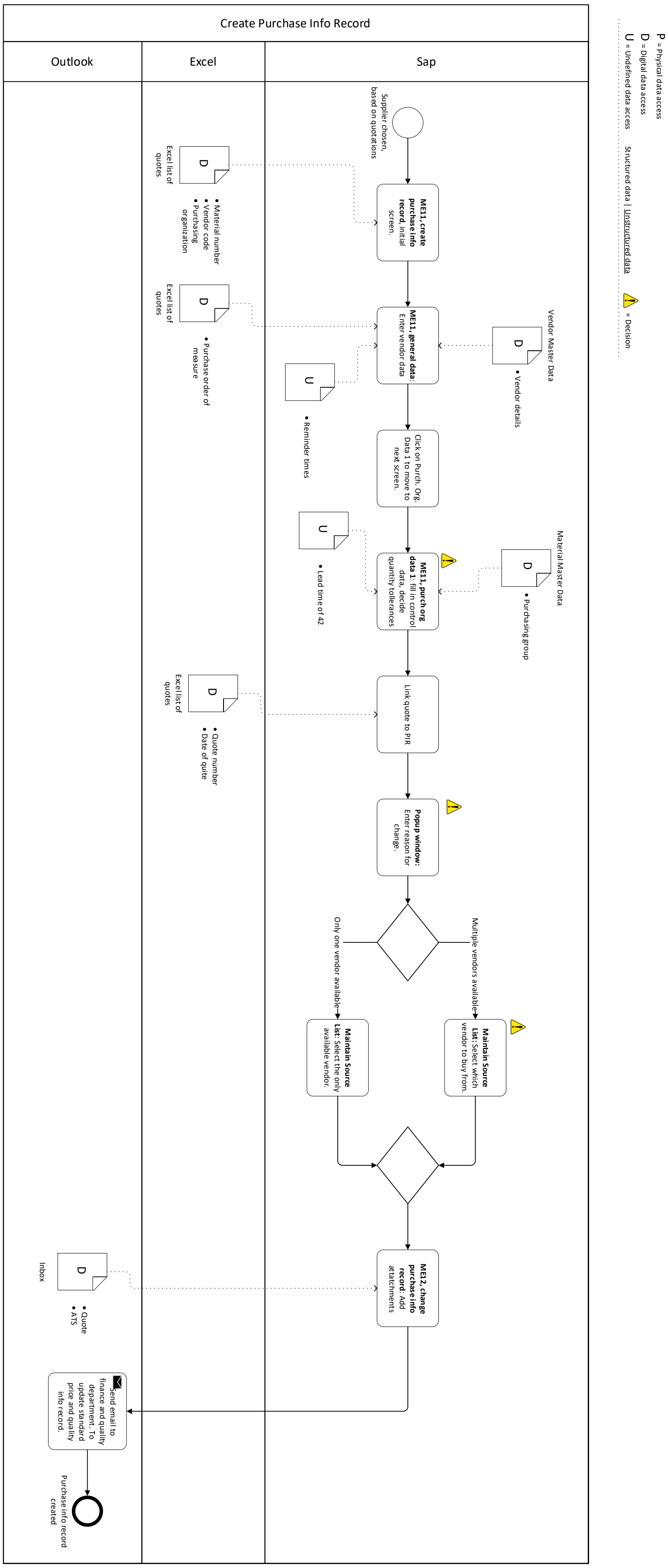

Figure J.3: BPMN-R model of process 3, creating a purchase info record.

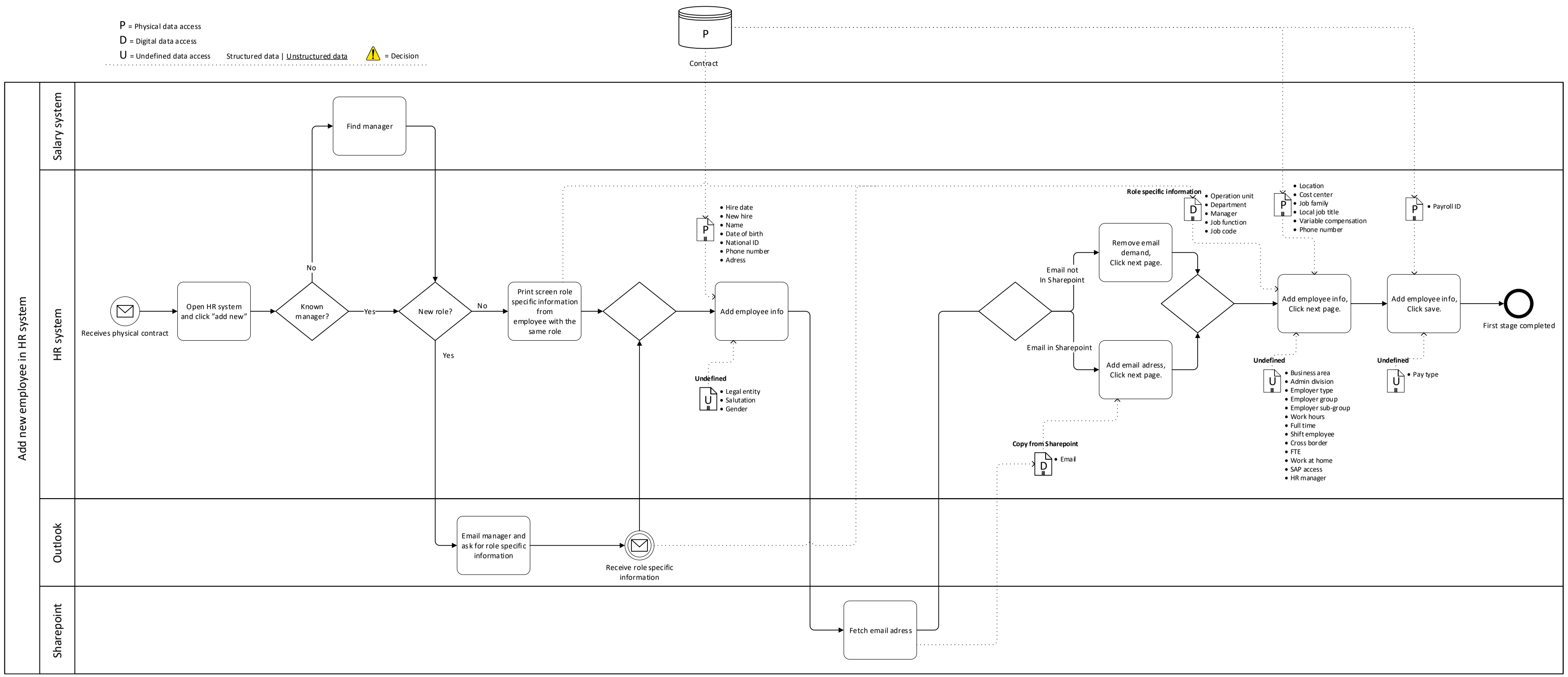

Figure J.4: BPMN-R model of process 4, adding an employee to HR system.

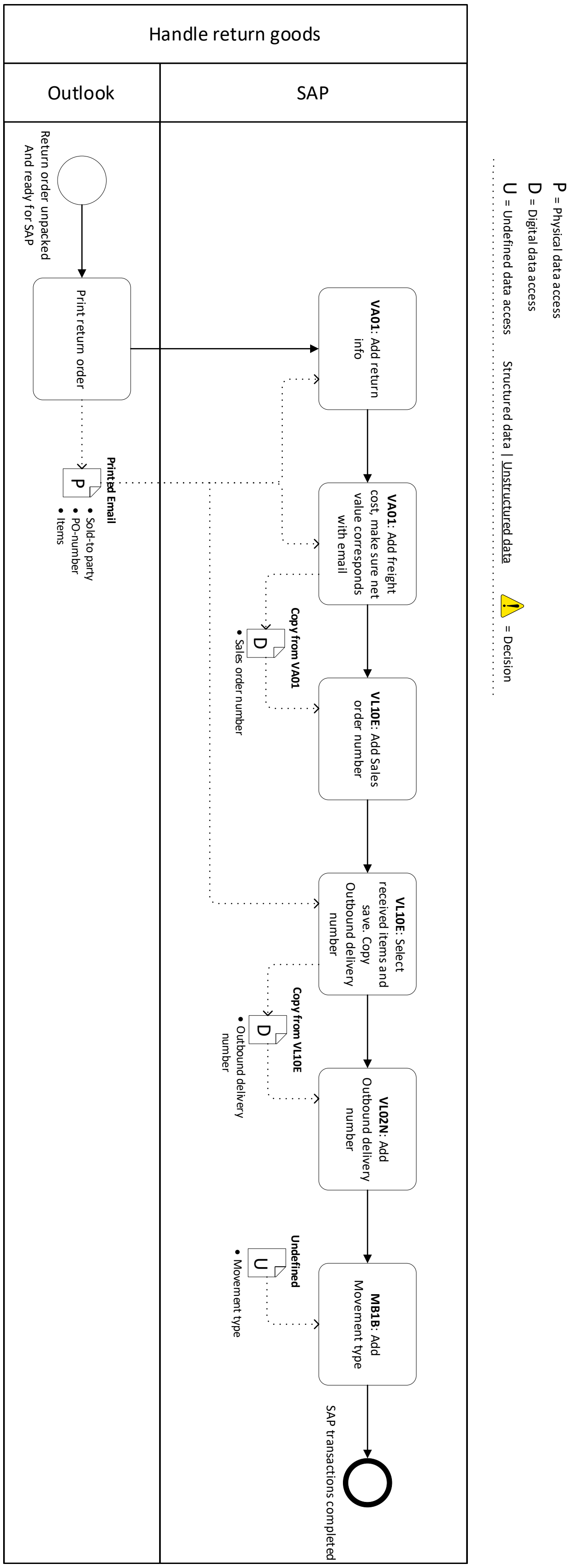

Figure J.5: BPMN-R model of process 5, handling of return goods.

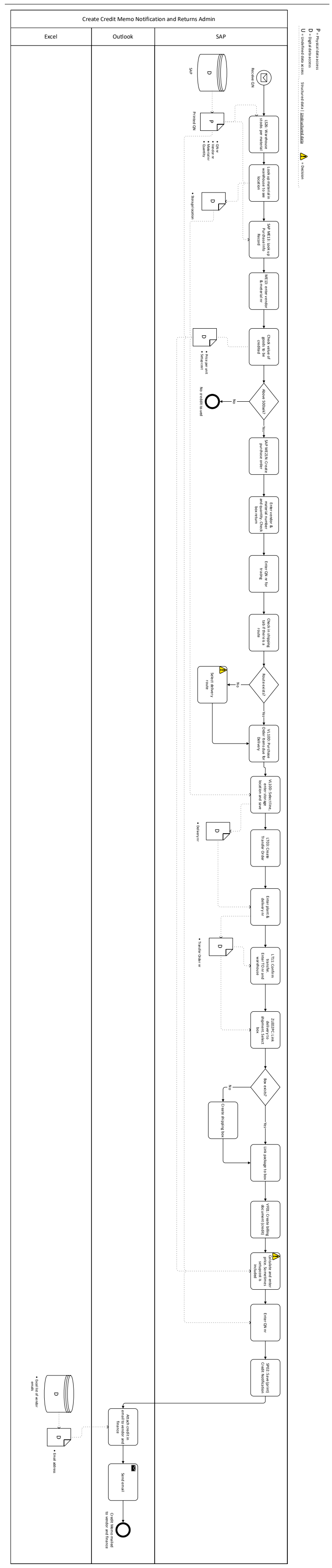

Figure J.6: BPMN-R model of process 6, creating and sending a credit memo notification.

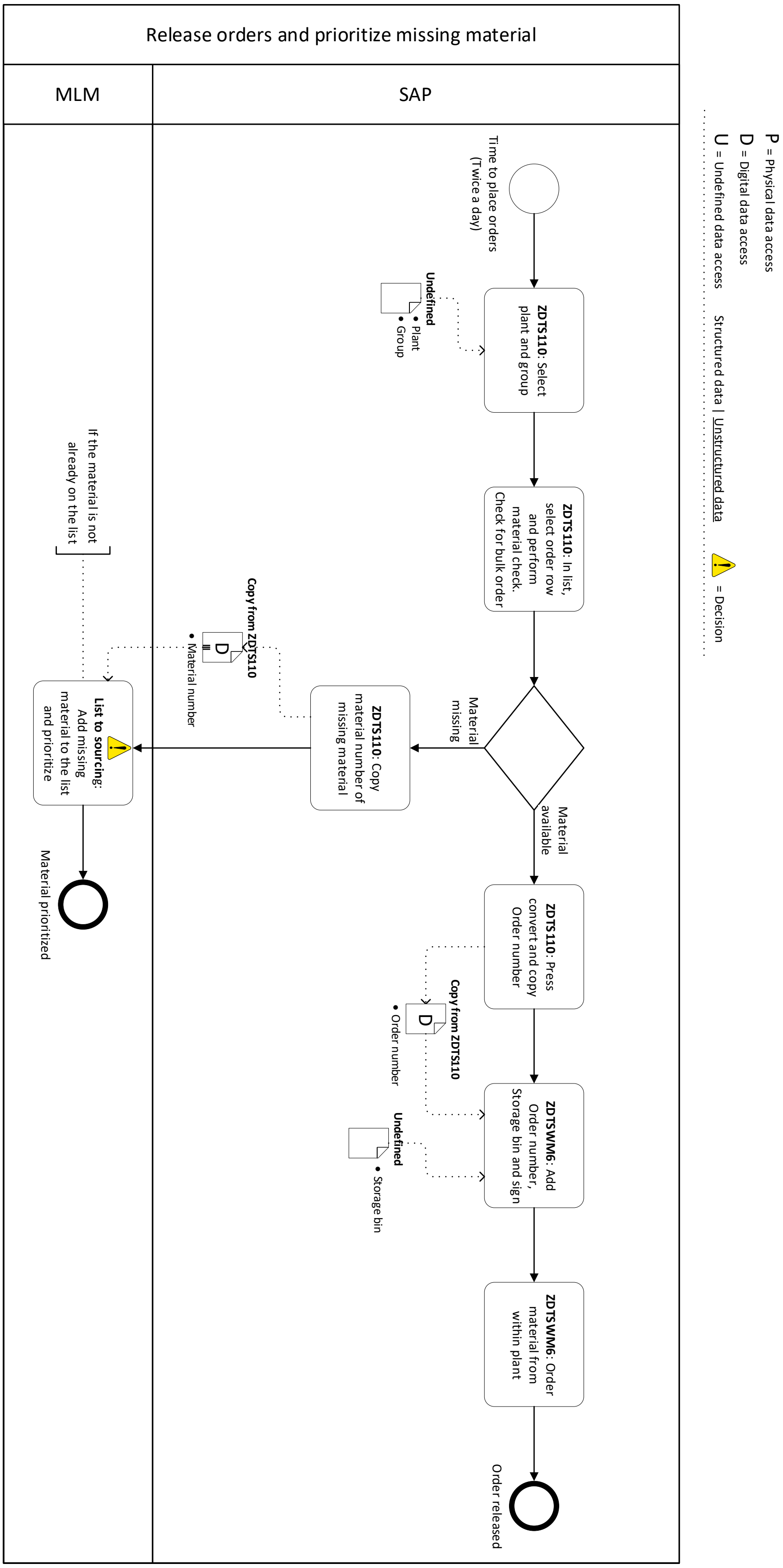

Figure J.7: BPMN-R model of process 7, releasing production orders.

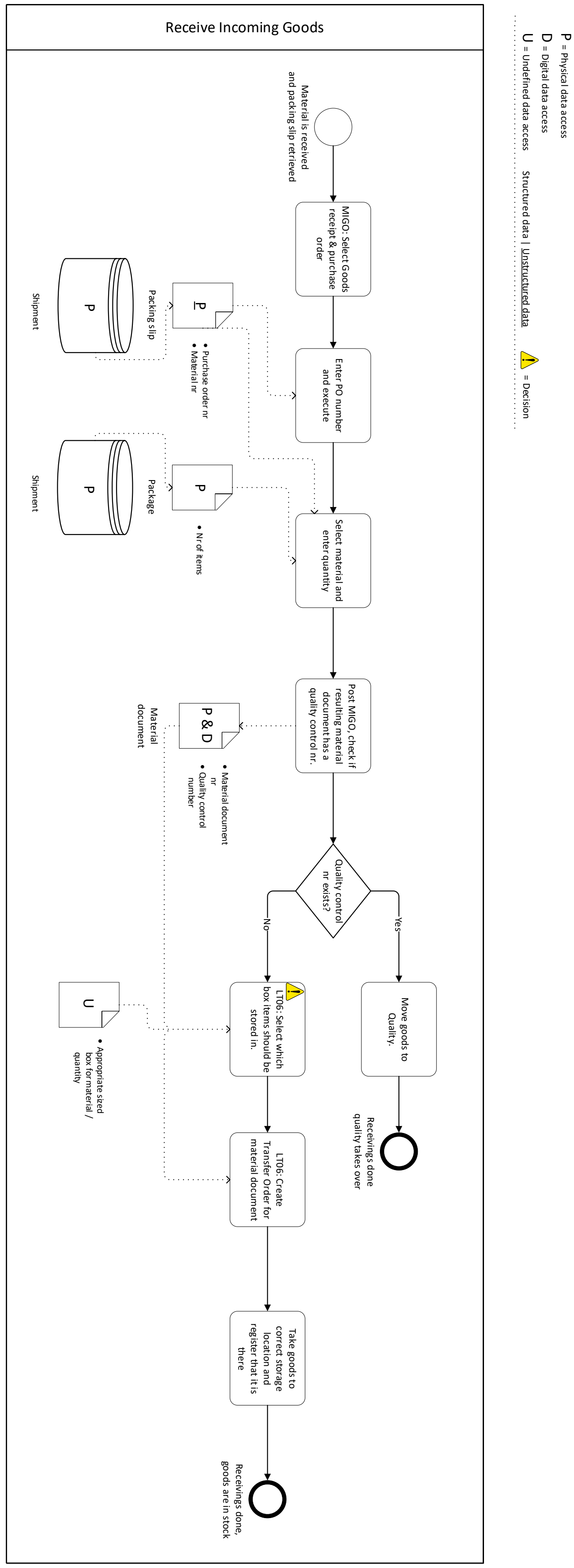

Figure J.8: BPMN-R model of process 8, receiving incoming goods.

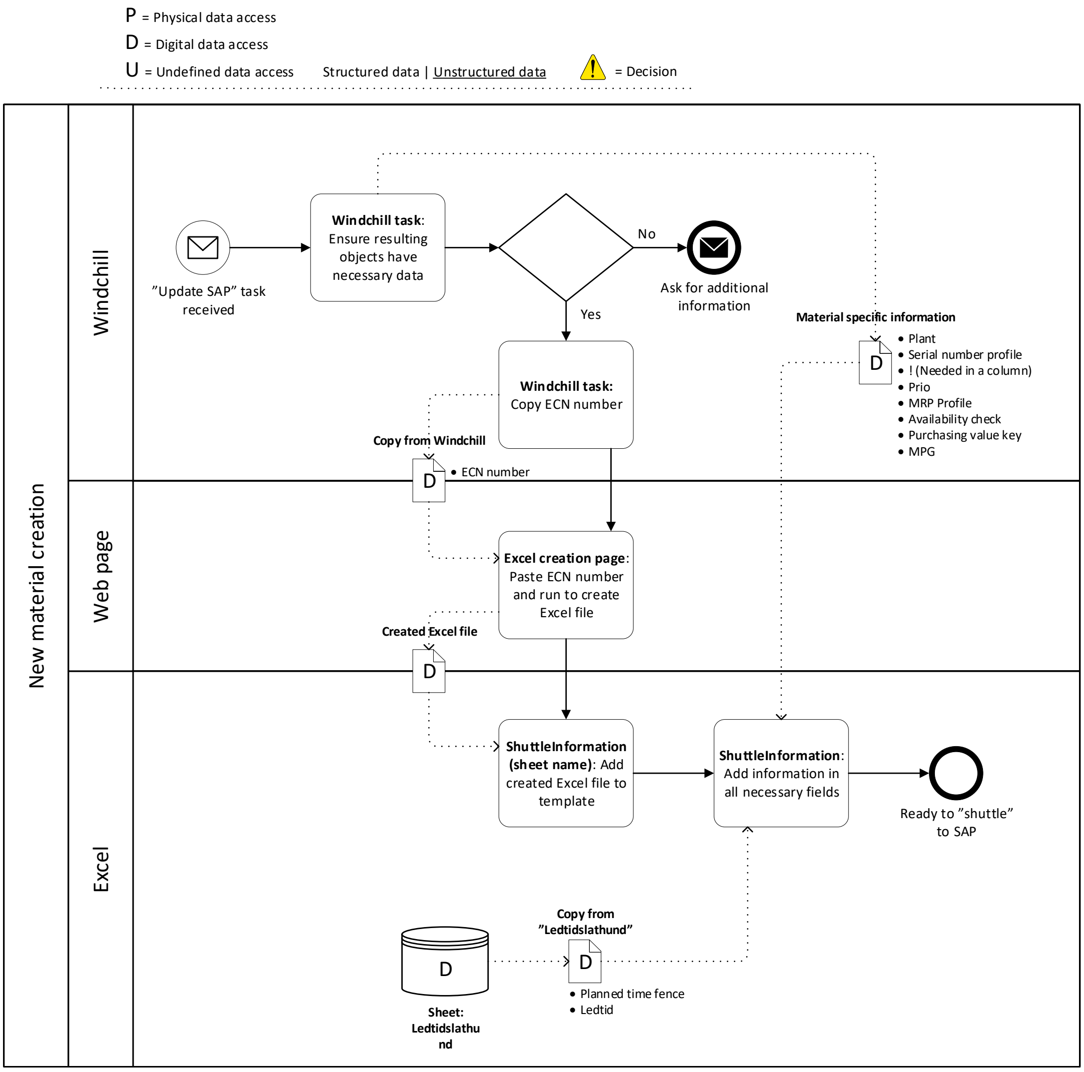

Figure J.9: BPMN-R model of process 9, new material creation.

Appendix K

Application of Criteria

Criteria	VK Update	Invoicing	Purchase info record	Add employe in HR system	Handle return goods	Create/Send CMN	Release production orders	Goods receivings	New material creation
Clear business value	x	x	x	x	x	x	x	x	x
Clear costs	x	x	x	x	x	x	x	x	x
Complex		x		x					
Computer based	x	x	x	x	x	x	x		x
Contains bottlenecks				x					
Critical in day-to-day operations	x		x				x	x	x
Data driven	x	x			x	x			x
Definable	x	x	x	x	x	x	x	x	x
Determenistic outcome	x	x		x	x	x	x	x	x
Digital data	x	x	x		x	x	x		x
Digital trigger	x								x
Error prone		x		x				x	x
Few exceptions	x	x			x	x	x		x
Fixed procedures	x	x	x	x	x	x	x	x	x
Fluctuating demand									
High risk									
High transaction volume	x		x		x	x	x	x	x
High transaction volumes or high value of transactions	x		x		x	x	x	x	x
Highly regulated									
Involve searching, collating or updating information	x	x	x	x			x		x
Limited human intervention	x	x			x	x	x	x	x
Low cognitive requirements	x	x	x		x	x	x	x	x
Low complexity	x		x		x	x	x	x	x
Low risk		x	x	x	x	x	x	x	x
Manual	x	x	x	x	x	x	x	x	x
Manual interaction with computer interface	x	x	x	x	x	x	x	x	x
Multiple systems	x	x	x	x		x	x		x
No government restrictions	x	x	x	x	x	x	x	x	x
No strategic fit	x	x	x	x	x	x	x	x	x
Performed at all hours									
Performing simple or complex decisions and algorithms	x	x	x	x	x	x	x	x	x
Potential for savings	x	x	x				x	x	
Redeployable personel	x	x	x	x	x	x	x	x	x
Redundant									
Repetitive	x	x	x	x	x	x	x	x	x
Routine	x		x	x	x	x	x	x	x
Rules based	x	x	x		x	x	x	x	x
Simple	x				x	x	x	x	x
Stable	x	x	x	x	x	x	x		x
Stable underlying systems	x	x	x	x	x	x	x	x	x
Standardized	x	x			x	x	x	x	x
Standardized data input	x	x		x	x	x	x	x	x
Strategic value									
Structured	x	x	x		x	x	x	x	x
Structured data	x				x	x	x		x
Structured sequence of sub-processes	x	x	x	x	x	x	x	x	x
Tedious	x	x	x	x	x	x	x	x	x
Time consuming	x	x	x		x	x	x	x	x
Time critical	x		x					x	

Figure K.1: Result of applying consolidated criteria on all processes.