MASTER

Comparing subject-oriented and classical business process models from the end-user perspective

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Comparing Subject-oriented and classical business process models from the end-user perspective

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“To discover new ways of doing something - look at a process as though you were seeing it either for the first or last time." ***Mitchel Martin***

Abstract

This study compares two different business process models mapped by two different modeling approaches. This comparison aims at examining the added value of a new process modeling approach called Plural process modeling. In doing so, two different processes were examined at company X and subsequently they were modeled with the classical modeling technique (EPC models) and the Subject-oriented process modeling technique (Plural models). The information for modeling the processes was collected through interviews conducted among the employees of the company.

After the processes were modeled the two different modeling approaches could be compared. This was done by conducting a non-empirical as well as an empirical study. In total 21 employees completed a questionnaire to examine the understandability as well as the perception of the employees on the two approaches. The results indicate that the different modeling approaches do not differ significantly from each other on both metrics as perception. Only significant differences could be found between the two RMA processes in terms of satisfaction and intention to use, which was in favor of the Plural model. Whether the new modeling method is therefore a beneficial addition to the domain of business process management remains unanswered and needs further research.

Preface

This master thesis is the result of a graduation project performed within the Operations department at company X. Being the last step of the master program Operations Management & Logistics it finalizes my life as a student. I have had a great time studying at Eindhoven and therefore I take this opportunity to express my gratitude to the people who have supported me throughout my studying career.

First of all I owe great thanks to my parents and my girlfriend Mieke; their continuous support, patience, motivation and confidence in me have very much contributed to a successful ending of my master program. Besides them I would like to thank my brother and sister for their support during my studies.

Cagatay Kibriscikli gave me the opportunity to perform this master thesis at the operations department of company X. On top of his normal workload he made time available for weekly meetings to discuss the progress of the project and the questions I had. Along with his valuable feedback and insights during these meetings it has improved my project a lot and therefore I owe him great thanks. I would also like to thank all of my colleagues at company X for their contribution to this study.

Furthermore, I want to thank my first supervisor, Oktay Türetken, for his input and energy he has put into my project. Although he had a very busy schedule, he found time to provide me with valuable feedback and answers to my questions. I would also like to thank my second supervisor, Irene Vanderfeesten, for her new insights and making me aware of the threats that have to be taken into account. Although our cooperation finished earlier than expected, I would like to thank Marco Comuzzi for his attention and advice during the time we worked together. I wish him all the best with his new job.

I would like to thank all my friends, especially Mark and Jasper who have helped me a lot with various courses throughout the master program. Also Ramon, our discussions while enjoying a HEMA breakfast during the exam weeks and master project has helped me stay on track during the master itself, but also motivated me to successfully finish my study.

Aldwin Schroot
Eindhoven, 2013

Executive summary

Due to increasing competition caused by i.a. globalization, organizations are confronted with optimizing their business processes in order to consolidate their position on the market. In general this competition leads to specialization, efficiency, technological and managerial improvements (Ibrahim, 2005). Therefore it is not surprising that Business process management (BPM) is getting increasingly popular among businesses to enhance performance (Indulska et al., 2009 & Trkman, 2010). It also indicates a domain that is under influence of an ever changing and improving environment. One of the aspects of business process management is business process modeling.

Although the classical way of modeling has had a lot of attention in the past, the business process management domain keeps on developing to improve the application of the method. The domain has been subject to some criticism as well by for example (Olbrich, 2011). The author argues that there are various issues that have to be solved. To reinforce his statements the outcome of the Taraneon process testlab[1] indicated that more than 90% of business process designs that were tested contained severe logical errors. Moreover, more than 70 warnings and errors per business process were found and almost half of the processes required changes after validation. Another issue is the duration of the BPM cycle. According to (Nakamura, et al., 2011) the challenge is to quickly understand the effectiveness and defects of defined processes. This cannot be done quickly enough due to the time that is needed to process them. When improvements have been discovered and are to be implemented the organization may already have been changed. And with an increasing changing business environment the usefulness of the method is doubtful. According to Reijers & Mendling (2008) complexity in large process models can be improved by the creation of subprocesses. The authors argue that by using such a modular design several advantages occur, including the ease of reuse, scalability and enhanced understanding. However there is still a lack of guidelines to apply modularity in a systematic way (Reijers & Mendling, 2008).

Therefore, a new approach has emerged from German academics, Subject-Oriented business process modeling (S-BPM). This approach is developed to reduce complexity of the existing models and increase the fidelity of business process creation and execution. This should lead to a more easily reaction on changing business environments.

[1] http://processtestlab.com/

However, it is not yet clear whether this new modeling technique is a beneficial addition to the business process management domain. Therefore, in this research a comparison was made between the classical (Flow chart EPC's) and the new developed subject-oriented way of modeling business processes (Plural models). In order to do so the following research question was formulated:

Is the derived model from the subject-oriented business process modeling technique a beneficial addition to the business process management domain?

Two different processes (RMA process & Training process) at company X were modeled in both ways to form the basis for this comparison see figure 1.

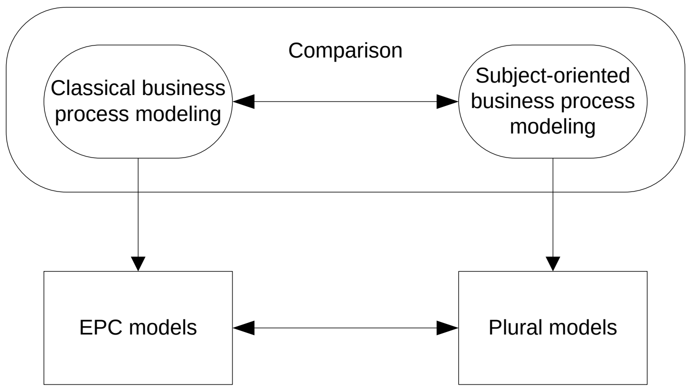

Figure 1: Comparison design

In order to map the processes in the classical way the as-is modeling method by Schwegmann & Laske (2003) was used which consists of five phases (Figure 2).

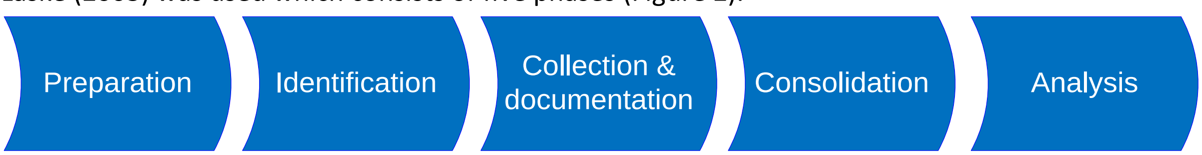

Figure 2: As-is modeling phases

An important aspect is the collection and documentation of the processes. This was done by interviewing twelve employees at company X related to the two processes. This information formed the basis for mapping the processes in the classical way. In order to map the processes in the Plural way the same information could be used, however additional information was needed in order to complete the process models.

The comparison of the classical and subject-oriented process models was done using a non-empirical as well as an empirical research. The non-empirical research consisted of metrics that measure the understandability and complexity of process models. Although a lot of metrics have been defined in literature, only a couple of them are proven to be related to the understandability of process models. The density metric and the average connector degree have been confirmed to be significantly correlated to the understandability of process models (Mendling, Reijers, & Cardoso, 2007) (Vanderfeesten, Reijers, Mendling, Aalst, & Jorge, 2008). Therefore, in addition to the simple count metrics, for the purpose of this research, these two variables were computed to judge both models on their understandability and were derived from Mendling (2007).

The results of the metrics analysis indicated that the metrics did not provide enough information to determine how understandable the process models are, especially due to the non-significant differences between the metrics. On the basis of the #nodes, #arcs and #tasks metrics it is expected that the Plural model might be more difficult to understand than the classical model. This is confirmed by the average connector degree metric which shows that the classical model scores slightly better than the Plural model. The density metric, however, contradicts to these metrics, but this can be explained due to the different sizes of the models which makes comparison of this metric fairly difficult. Because of this result further analysis was done by performing an empirical research.

The empirical research consisted of a survey, conducted among 21 participants of the company. By the use of statistical analysis, an attempt was made to compare the models on different vaiables.

The questionnaire consisted of three parts. The first part of the questionnaire consisted of demographical questions like age, position in the company, working years, etc. The second part consisted of six questions that measured the understandability of the models which resulted in a SCORE variable. These six questions were also timed, which could give an indication about the difficulty of the questions. The last part consisted of perception based questions based on the theory by Moody (2003), Seddon & Yip (1992) and Maes, Poels, Gailly, & Paemeleire (2005).

The following table summarizes the results of the empirical study:

Hypothesis	Accepted/rejected	Short explanation
H1: The amount of time participants spend on the understandability questions takes less time for the classical models than for the Plural models.	Results inconclusive	The classical RMA model does take less time (although not significantly), however, for the training model this is not the case. There might be a learning effect that influences the results.
H2: The classical models are more positively related to the SCORE of the understandability questions than the Plural models.	Results inconclusive	On both process models the SCORE is higher for the classical models, however not significantly. The hierarchical structure of the Plural models might be the cause of the difference.
H3: The classical models score higher on the perceived factors than the Plural models.	Results inconclusive	The classical training model does score higher on the perceived factors, although with the exception of PEOU. The classical RMA model however scores lower. It is difficult to give an explanation for this result. Again these differences were not statistically significant.

Table 1: Summary conclusions hypotheses

The results of the empirical study did not show any statistical significant differences between the Plural and classical models. Also the results between the two models were not consistent. Therefore the results of the hypotheses remain inconclusive. The contradicting results indicate that more research is needed to judge whether the Plural models are better in terms of understandability than the classical models. Whether the new modeling method is therefore a beneficial addition to the domain of business process management remains unanswered and needs further research.

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List of abbreviations

3PL	3rd Party Logistics
7PMG	7 Process modeling guidelines
AM	Account manager
BPM	Business Process Management
BSC	Balanced Scorecard
CRM	Customer relationship management
EPC	Event driven Process Chain
ERD	Entity Relationship Diagrams
GAM	Goal-Attribute-Measure
GQM	Goal-Question-Metric
IS	Information Systems
ITU	Intention to use
Mdn	Median
PEOU	Perceived ease of use
PU	Perceived usefulness
RMA	Return Material Authorization
S-BPM	Subject-oriented Business Process Modeling
SNUTT	Serial NUmber Tracking Tool
TSS	Technical Support Specialist
UIS	User information satisfaction

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1 Introduction

Business process management emerged in the 1960's when technology increasingly became a business driver and enhanced the rate of change. Ever since many methodologies on the design of process models have been developed and adopted by industry. Therefore, a vast amount of techniques and methods are nowadays available such as ERD's, Object-oriented techniques and Subject-oriented techniques. In this research a comparison was made between the classical and the new developed Subject-oriented way of modeling business processes. The processes at Company X were modeled using EPC's for the classical technique and Plural for the subject-oriented technique to form the basis of the comparison see figure 1.

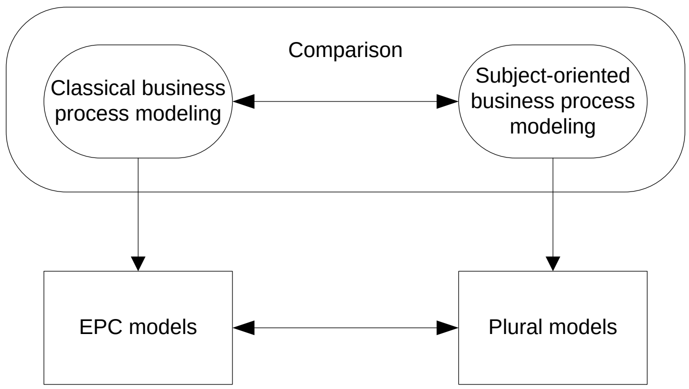


Figure 1: Comparison design

The models were then tested according to metrics on process models and the perception of the employees on these models, particularly the understandability. The results found showed whether the new method is beneficial for the business process management domain and serve as a mean for lessons learned on modeling the Plural method as well as the classical method.

Section 1.1 discusses the problem background for this research followed by section 1.2 which introduces the research questions. Sections 1.3 and 1.4 describe how the two modeling methods are applied to the processes. Next, section 1.5 describes the evaluation of the designed process models. The models were derived from the processes at Company X which are described in the case study in section 1.6. Finally this chapter ends with an overview of the structure of this report.

1.1 Problem background

Due to increasing competition caused by i.a. globalization, organizations are confronted with optimizing their business processes in order to consolidate their position on the market. In general this competition leads to specialization, efficiency, technological and managerial improvements (Ibrahim, 2005). Therefore it is not surprising that Business process management (BPM) is getting increasingly popular among businesses to enhance performance (Indulska et al., 2009 & Trkman, 2010). It also indicates a domain that is under influence of an ever changing and improving environment.

Business process modeling is developed to enhance the performance of the company. One of the priorities is the need for companies to identify and better understand their processes (Elzinga, Horak, Lee, & Bruner, 1995). Especially with an increasing amount of automation of processes, understanding them is very important. This is supported by a study of Indulska, Green, Recker & Rosemann (2009) who formulated a top 3 of business process modeling benefits:

1. Process improvement
2. Understanding
3. Communication

This top 3 indicates that for practitioners it is important to gain understanding of the processes involved in the organization. As a result it requires the models themselves to be understandable. Therefore, it is necessary to use a technique that provides a model that is easy to use and understand and is beneficial for process improvement.

Although the classical way of modeling has had a lot of attention in the past, the business process management domain keeps on developing to improve the application of the method. The domain has been subject to some criticism as well by for example (Olbrich, 2011). The author argues that there are various issues that have to be solved. To reinforce his statements the outcome of the Taraneon process testlab[2] indicated that more than 90% of business process designs that were tested contained severe logical errors. Moreover, more than 70 warnings and errors per business process were found and almost half of the processes required changes after validation. Another issue is the duration of the BPM cycle. According to (Nakamura, et al., 2011) the challenge is to quickly understand the effectiveness and defects of defined processes. This cannot be done quickly enough due to the time that is needed to process them. When improvements have been discovered and are to be implemented the organization may already have been changed. And with an increasing changing business environment the usefulness of the method is doubtful. According to Reijers & Mendling (2008) complexity in large process models can be improved by the creation of subprocesses. The authors argue that by using such a modular design several advantages occur, including the ease of reuse, scalability and enhanced understanding. However there is still a lack of guidelines to apply modularity in a systematic way (Reijers & Mendling, 2008).

Therefore, a new approach has emerged from German academics, Subject-Oriented business process modeling (S-BPM). This approach is developed to reduce complexity of the existing models and increase the fidelity of business process creation and execution. This should lead to a more easily reaction on changing business environments. The hype cycle developed by Gartner (Dixon & Jones, 2011) shows that it is just launched and needs to develop during the upcoming years.

[2] http://processtestlab.com/

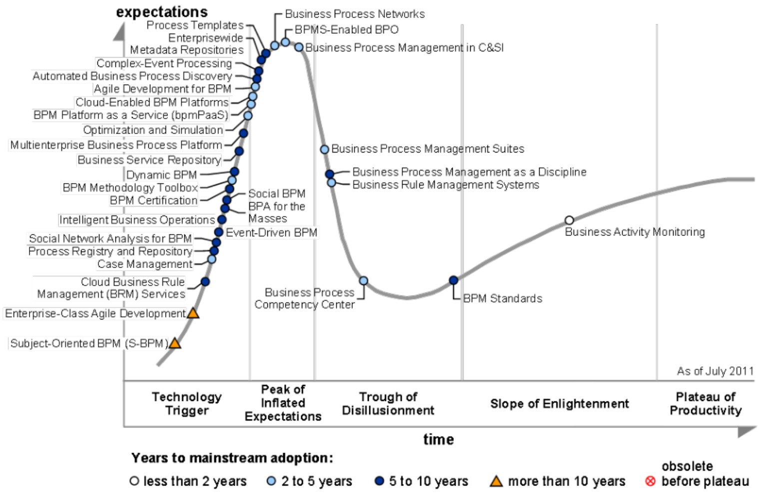


Figure 2: Gartner hype cycle (Dixon & Jones, 2011)

These new developments also involve a new processing modeling method, Plural. The method is described as being beneficial to the field in terms of time management and efficiency (Turetken & Demirors, 2011). However, the models generated with this new method are not yet compared to models generated with different methods. Also the other techniques were typically evaluated using students or experts that are already familiar with process modeling. Therefore, the literature has not yet indicated whether the derived models from either modeling technique are beneficial in a business environment. This way the following research questions can be formulized:

Main Research question

Is the derived model from the subject-oriented process modeling technique a beneficial addition to the business process management domain?

A beneficial addition in this context can be defined as the understandability of the models and the perception of end-users.

Sub questions

In order to answer the main research question, different sub questions have been formulized. The main direction of this research is to make a comparison between two different types of models. In order to do so, at first it is necessary to know the main differences between the two modeling techniques. Therefore, the following sub question is formulized.

RQ 1: What are the main differences between classical business process modeling and subject-oriented business process modeling?

When the differences between the two modeling techniques are clear, the techniques should be comparable. However, it must be clear how the outcome of the two modeling techniques can be compared. This leads to the following research question.

RQ 2: In what way can the EPC model and the Plural model be compared?

From the previous sub question the next sub question can be derived. The comparison of the models is also about the users' perception. This perception needs different variables to compare the models, as the following question shows.

RQ 3: What are the key issues for employees in judging the models?

Because both methods have used different techniques and approaches it is under influence of preferences by users. This preference might lead to different insights in this domain, as an addition the following question is formulated.

RQ 4: What can be learned from the way the processes are modeled by two different techniques which involve different approaches?

Finally, in order to incorporate the perceived ease of use of the methods, the following question is formulated.

RQ 5: Which one of the two types of models (EPC and Plural) has a preference relating factors such as time, quality and readability of a model in a business environment?

Besides these research questions formulated for this study, an attempt was made to improve the processes at Company X using the modeled processes. A separate document was created with all challenges that Company X faces with these processes and recommendations were formulated to solve these challenges. The relation between the search for these challenges and the designed process models is more in depth explained in chapter 6.

1.2 Research design

In order to answer the research questions, first a literature study was performed. Also interviews were conducted with employees at the company and data from the processes that were available was studied. This information was used to document the processes, which lead to the process models which are the basis of this study. Subsequently, a survey was formed which was first tested and then conducted with the employees at the company. Furthermore, an extensive empirical and non-empirical analysis was done to answer the main research question. An overview of the research design is given in figure 1. Because the research involves the comparison of two different models it was important to execute the project with caution to prevent bias. At first the classical modeling technique was used to define and describe the processes of both areas.

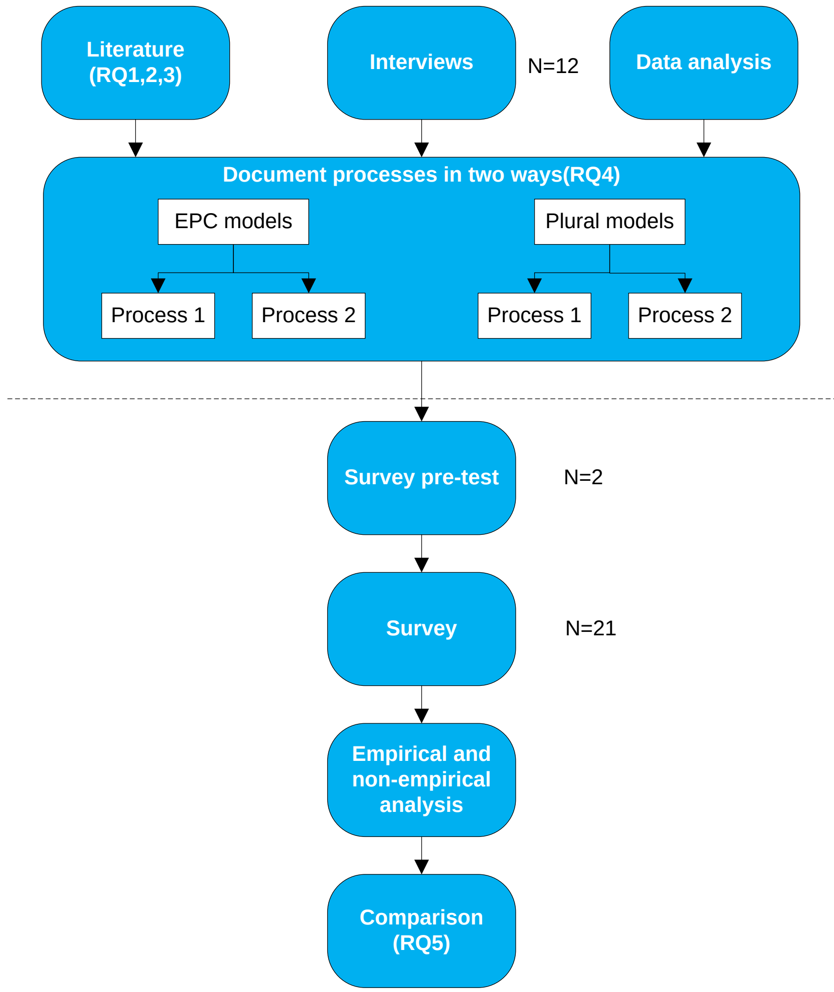


Figure 3: Research design

1.3 Design of the classical models

As-is modeling was used to capture the detailed data related to the processes and analyze the currently performed processes (Schwegmann & Laske, 2003). Although As-is modeling has its limitations as it might limit the creativity of the participating employees, has a risk that old processes will enter the succeeding To-be modeling phase and can be very time consuming and therefore expensive, the benefits outweigh these limits (Schwegmann & Laske, 2003). This project searches for potential improvements by identifying all the shortcomings and problems. It is also beneficial to all the participants to understand relevant relationships and existing problems. These are important arguments for using As-is modeling besides other arguments mentioned by Schwegmann & Laske (2003). Furthermore, the authors provide a guideline on how to apply As-is modeling in practice. This guideline consists of five phases, which starts with the preparation, followed by the identification and prioritizing of problem areas to be collected. Next the As-is models are being collected and documented. After that the as-is models were consolidated and finally analyzed and evaluated. These five phases were used as a guideline for the As-is modeling part of the project, see figure 2.

Figure 4: As-is modeling phases

- **Preparation,** which involves the definition of goals and identifying potential information sources.
- **Identification,** the identification phase involves the description of the problem area and the parts that are important. **Collection and documentation,** this phase involves the collection of the data via interviews and the documentation of these interviews.
- **Consolidation,** during this phase the models created in the previous phase were merged together and structured.
- **Analysis,** at last the criteria have to be set up to analyze and evaluate the created model.

Collection and documentation

As the preparation phase and identification phase are already discussed, the design continues with the collection and documentation phase. In order to collect the information of the processes, the employees involved need to be interviewed. This was done according to the knowledge elicitation interview theory. This theory is developed for collecting information for the development of process models and other applications.

According to Goseva (2006) interviewing is not simply a matter of asking the right questions. It requires the development of some general skills, the ability to listen and knowledge of a variety of interviewing tactics. According to the author interviewing consists of four phases:

1. Identifying candidates, the first candidate should be the person who is responsible for the entire process. By analyzing the organizational chart other relevant people can be identified.
2. Preparing for an interview, the second phase consists of two major activities. The first activity is making arrangements with the people who are to be interviewed. The second activity is to prepare a list of questions (Appendix C)
3. Conducting the interview, this phase consists of introducing yourself and make clear what the goals of the interview are. Furthermore the interviewer should listen actively, be courteous, remain in control and use non-verbal communication techniques. Also the interviewer needs to keep the interview on track and address the questions in context.
4. Following up, the interviewee should get a written expression of thanks.

This guideline was used to perform the interviews. The employees that were interviewed to capture the complete processes of both the RMA process and the installation service can be found in Appendix A. For each interview one hour was scheduled. This list of involved employees was composed together with the operations director to make sure everyone is incorporated; a top down approach was used starting with the manager supply chain management.

The employees who were interviewed were informed in advance via e-mail (Appendix B). In this e-mail the interviewer was introduced and the project was explained. With the explanation of the project the reason for the person to be interviewed was explained as well. It is important to collect the process as it is, and not as it should be. Therefore, it has to be clear to them that for this project to become a success it is necessary to capture the real process and that it is by no means to control them on their work.

The information from these interviews was used to model the different processes involved in the two areas of interest. The modeling of these processes was done using the guidelines of process modeling (Becker, Rosemann, & Uthmann, 2000). Furthermore Event-driven process chains (EPC) was used as a classical modeling language as the new process modeling technique Subject-oriented process modeling using the Plural method is also based on this language, this way a better comparison could be made. Also an EPC-like notation seems to be more understandable than for example the use of Petri nets (Sarshar & Loos, 2005). There are multiple tools that can be used to capture these processes. ARIS Business Architect was used in this case as the tool supports a variety of modeling notations including EPC's and is extensively used in practice for modeling and analyzing business processes. Moreover, ARIS is recognized by The Gartner Group as a market leader in process modeling.

Consolidation

In this phase all models captured in the previous phase were integrated to create a total model. Important was to structure the model and standardize the terminology that was being used.

Analysis

The criteria that were used in order to analyze the complete model that was created in the consolidation phase are defined in section 3.1. Furthermore reference models were used to compare them with the current process and when necessary improvements to the model were made. Furthermore as part of the evaluation the process was checked with the employees to make sure it was correct.

In order to compare the model derived from the classical modeling technique with the new modeling technique, all parts of the process were measured with respect to time. As a consequence an indication could be given on how much time one needs for modeling the process in the classical way.

1.4 Design of the Plural models

This modeling technique involves a different approach to modeling processes. The focus of this approach is on the subject. The information for modeling the processes according to this modeling technique involves in general the same information as being used for the classical method. Although the theory of the Plural modeling technique mentions that employees themselves can document the process via this technique, in practice it might be difficult as the employees must be familiar or be trained in performing this technique. Therefore the interviews that were performed for the classical method also form as the main source for modeling in the Plural way, thus the processes were not modeled by the employees, but by the researchers. This could lead to a biased research and therefore the verification of the models was executed by a process modeling expert. From a company perspective the models were validated by the supply chain manager. The model was processed in ARIS Business Architect with the same modeling language as the classical method. This way the models could be better compared, because the influence of these variables (tool and language) could be controlled.

1.5 Evaluation of the two models

In order to evaluate the two different types of models multiple evaluation techniques can be selected. A choice can be made between empirical and non-empirical evaluation techniques. For the purpose of this research both an empirical and non-empirical technique was selected. As for the non-empirical technique a choice was made for the metrics approach. This approach analyses the complexity-based features of methods based on a standardized set of method metrics (Siau & Rossi, 1998). But in order to validate the models an empirical technique was used. Because the purpose of this research is the comparison of two models, modeled with different approaches, information is needed on attitudes, opinions, impressions and beliefs of human subjects; a survey is therefore selected for the empirical approach.

1.6 Case study

The case study was performed at Company X, which is a service provider in the telematics industry. The company enables more effective fleet management by providing real-time business insights for transport and logistics companies of all sizes. They give fleet operators reliable integrated control of their entire operations, so they can make the most productive use of their human and vehicle assets to run profitable businesses.

The business is transitioning from a single product offering in the long-haul segment of integrated transport operators to a more complex product and service offering. This enables more effective fleet management and increases their market reach through the development of indirect channels. Together with the rapid changes in underlying technologies in the recent past, the operations and customer service models are being constantly evaluated, redesigned, and simplified to achieve the vision while keeping a robust, scalable, and effective operational and customer support model and structure. Within this domain two processes can be distinguished that are facing challenges for the operations department.

The first process is the installation service. In order to provide the fleet management service a black box has to be installed in the truck. This installation can be done in various ways. Historically Company X provided either an installation training to customers that operated large fleets and had their own technical facilities and personnel that were capable of performing hardware installations (our product) or provided customers who did not have such capability with a list of qualified Service Centers, which are 3rd party and typically small companies, and asked the customers to arrange the installations at their own expense with such providers. As Company X is entering a more indirect distribution channels and some of their new direct customers wish to receive an end-to-end product enablement from them, they are in the process of setting up the installation of a product as a service that they can sell. They have already some actual experience of selling such a service, but the scale of this offering throughout the markets in Europe requires a significant review of their process and supplier capabilities, internal procedures to be able to handle this as a service offering, and the setting up of an effective framework within which this service can be offered, performed with a high process quality, and results in a profitable service offering on its own.

In other words, Company X challenge is to provide an installation service to customers (transport companies) and develop a (new) service offering to resellers / customers for installations. As installation is the start of the deployment of their product and all of the services rely on an efficient and robust installation, it is a key process for the quality, but as installation means customer truck downtime, the timeliness and efficiency of this process is essential for their customers.

The second process that is an important domain in customer service nowadays is the return logistics process at Company X. Historically Company X sold their products with a standard 12 month warranty and in some exceptional cases up to three to five years of extended warranty. For product defects under warranty, a Hotline troubleshooting guide was set up to establish hardware defects and authorize a RMA (Return Material Authorization). In order to provide continuous service to their customers, an advance replacement process was developed which means that the defective unit is replaced within 48 hours and the final defect analysis should happen shortly after the RMA request. However, this process has been problematic and inefficient, resulting in multiple challenges within their operations.

As Company X is facing increased demand for extended warranty from their direct customers and indirect channels, as well as more requests for rental units (which means Company X is liable for hardware defects), the RMA process needs to be reviewed and where possible simplified or changed.

It should be noted that the Service Centers referenced above are also typically used on a case by case basis, for hardware troubleshooting, de-installation, etc. that may relate to a RMA ticket. This is the case when there is an extended warranty obligation which may include de-installation and re-installation, linking this topic and the use of 3rd Party Service to the Installation Services topic above.

In order to provide solutions for the challenges Company X is facing, the processes of both the installation service, as the return logistics were modeled. To keep the research within a manageable scope, the product scope can be defined as Product A (with display), so that product related differences can be left out of scope.

1.7 Report structure

This report is structured as follows. Chapter two starts with the theoretical background, which was used in the case study. More specifically, section 2.1 elaborates on the classical way of business process modeling. Section 2.2 subsequently explains the Plural business process modeling technique. The last section of the chapter explains in what way these two process models can be evaluated.

Chapter three explains the design of the process models. Section 3.1 introduces the guidelines that have been used, followed by section 3.2 which explains the model quality aspects that have to be taken into account. Subsequently, the modeling notation is explained, after which the designed process models are explained in section 3.4. The chapter ends with a summary of the involved information systems in the processes.

In chapter four the non-empirical evaluation of the process models is covered. The business process model metrics are computed and the results and conclusion of the evaluation are described.

Chapter five elaborates on the empirical evaluation of the process models. The allocation of the groups is explained in the first section, after which the design of the questionnaire is clarified. Furthermore the selection of participants and the design of the questionnaire are explained. These sections are followed by the hypothetical relations between factors and understandability. In section 5.6 the results are explained followed by the conclusion.

In chapter 6 the lessons learned are clarified. This incorporates the lessons learned of the interviews, modeling the processes, opinions and remarks of the participants and the relation between the models and the challenges that have been found.

Chapter 7 ends this report with discussing the conclusion, discussion, limitations and theoretical and practical contribution of this study.

2 Theoretical background

This chapter elaborates on the literature related to the topics discussed in this thesis. The first section discusses classical business process modeling with all its facets. Section 2.2 explains the new way of business process modeling called Plural. The last section eventually covers the theoretical background of comparing two process models.

2.1 Classical business process modeling

Business process management emerged in the 1960's when technology increasingly became a business driver and enhanced the rate of change. This led to a different approach on operational business, the focus shifted towards process optimization (Lusk, Paley, & Spanyi, 2005). This continued in the 1970's and 80's where programs as Just in time and Total Quality management were introduced. In the early 1990s workflow management emerged as a new technology to support business processes. This led to new business administration concepts such as process innovation (Davenport, 1993) and business process reengineering (Hammer & Champy, 1988). Currently, business process management can be seen as an important research area that combines insights from different perspectives.

According to Van der Aalst et al. (2003) BPM is a set of methods, techniques and tools to support the design, enactment, management and analysis of operational business processes. One important aspect of business process management is the documentation of the processes that are involved in the organization. This is done by the creation of business process models. Figure 3 shows the different components from business process modeling (Mendling, 2008). In order to execute process modeling, a decision has to be made which modeling technique is going to be used.

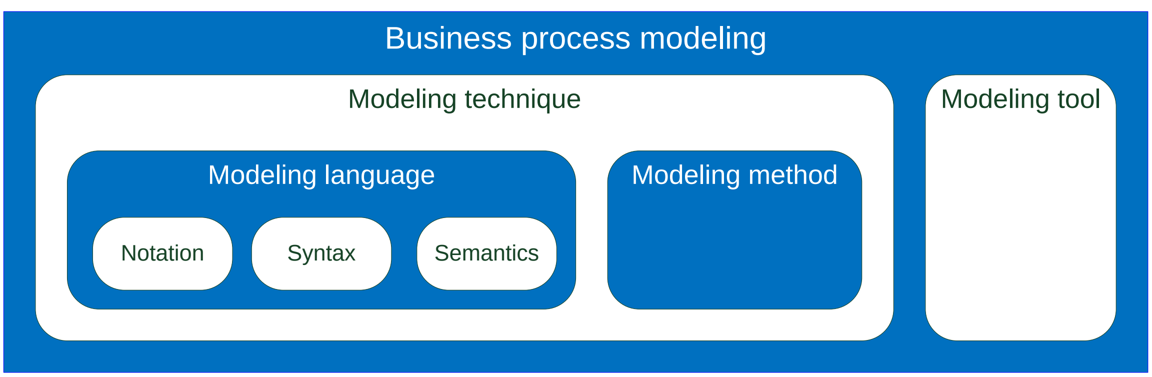


Figure 5: Business process modeling elements (Mendling J. , 2008)

Throughout the development of BPM various different modeling techniques have emerged. Giaglis (2001) elaborates on six different business process modeling techniques, however the definition of a modeling technique is subject to interpretation as some techniques have been defined as modeling languages (table 1).

Business process modeling techniques
Flowcharting
IDEF techniques
Petri nets
Simulation
Knowledge-based techniques
Role activity diagramming

Table 1: Modeling techniques (Gialis, 2001)

For the purpose of this research the focus is on the business process modeling techniques, as the information that was analyzed in the case study are the business processes. The techniques from table 1 are explained in short:

Flowcharting: one of the first graphical modeling techniques. Documents the overall structure of a system and shows the information flows (Jones, 1986). Examples of flowcharts are an Event-Driven process Chain (EPC) and BPMN.

IDEF techniques: IDEF can be divided into three independent techniques, function modeling, data modeling (IS) and process description modeling. The techniques model processes and data structures in an integrated fashion (Giaglis, 2001).

Petri nets: Give a more mathematical/graphical model of systems to analyze the structure and dynamic behavior of modeled systems (Peterson, 1981).

Simulation: The creation of a model that is similar to the real-world system in order to simulate certain alternatives when the system is changed (Doran & Gilbert, 1994).

Knowledge-based techniques: In process modeling applications this technique has emerged and is based on artificial intelligence (Hedberg, 1996). The purpose is to link business processes to organizational rules and objectives (Yu, Mylopoulos, & Lesperance, 1996).

Role activity diagramming: The focus of this technique is on the individual or group roles within a process. Their relationships, interactions and activities were explained via such a diagram (Huckvale & Ould, 1995).

The technique that was used for this research is the flowcharting technique, which is called the classical way of modeling. One way of applying this technique is via Event-driven process chains (EPC's). The EPC is a business process modeling language that shows the temporal and logical dependencies of activities in a business process (Mendling & Aalst, 2007). EPC's consist of elements decribing the activities and elements describing the events, which alternate each other. An activity is an active component and describes the task. An event however, is a passive component that causes an activity. A model starts with an event and ends with an event. Three type of connectors can be modeled in an EPC: AND, OR and XOR. The AND-split is used when all the following processing steps have to be performed and occur concurrently. The OR-split can be used in case at least one of the following steps have to be performed.

The XOR-split is used when exactly one of the subsequent branches have to be activated. An example of a simple EPC is shown below:

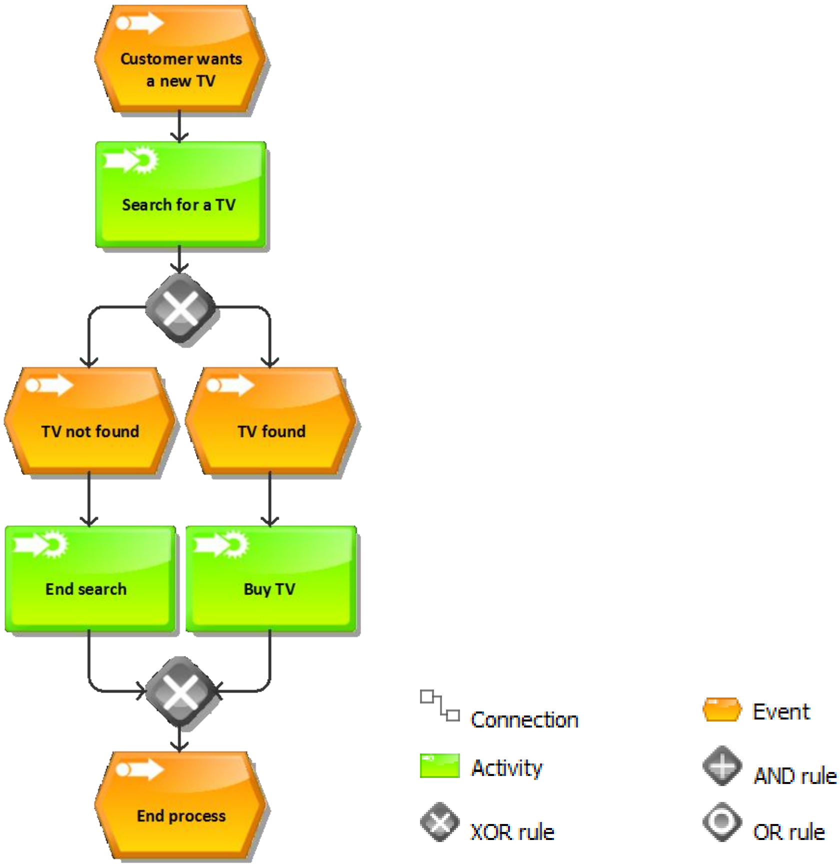


Figure 6: EPC process model

EPC's were used, because the Plural method (which is explained in the next section) uses EPC's for capturing process models as well. This way the influence of the modeling language could be controlled and so a better comparison could be made.

2.2 Subject-oriented business process modeling

As mentioned before new developments have taken place in the field of business process management, among which one of them is the new Plural method as part of the subject-oriented business process modeling technique. This method has a different approach to modeling business processes. The developers tried to create a method that enhances the way models are modeled. It is a decentralized and concurrent way of modeling. The authors developed the model, because they argue that traditional modeling, which is centralized, takes a considerable amount of time and is not optimal when processes change frequently. The Plural method leads to a quicker way of modeling parts of business processes by using the employees themselves to model their actions and so work concurrently. The employees are responsible for the understanding, modeling and improving the activities that must be performed for their jobs. The result of the employees will be integrated into complete process models at different abstraction levels which lead to diagrams that provide insight into the way the organization works and how it can be improved (Turetken & Demirors, 2007). The notation that is used for Plural models is the Event-driven Process Chain (EPC) notation. The Plural method is based on three phases which results in a processbase and the necessary infrastructure.

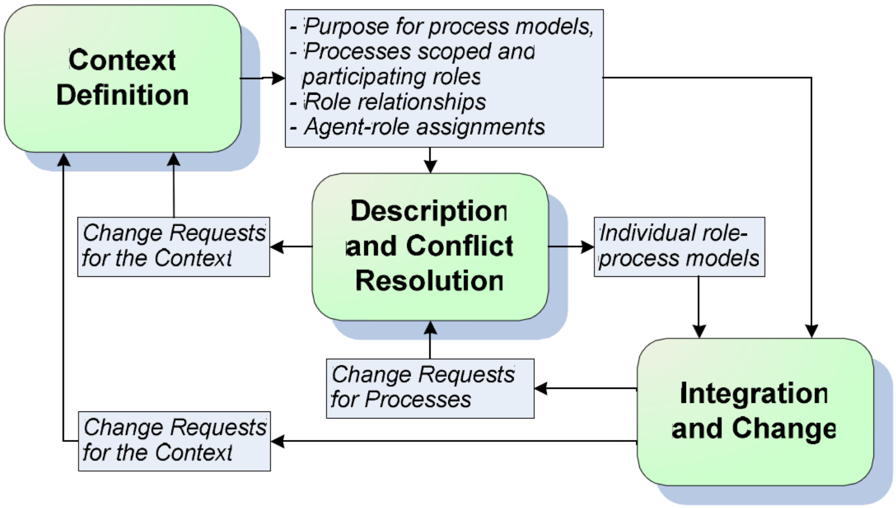


Figure 7: Phases of the plural method (Turetken & Demirors, 2007)

The first phase is the context definition phase. In this phase the aim and scope of the modeling process is defined by all process owners. In the description and conflict resolution phase the agents define their own activities based on the role they play in the organization. The agents have to reach consensus between their definitions which have to be validated by associated peer agents and verified by the coordination team. The final phase is the integration and change phase. This phase involves the merging of the completed models. When this is done, agents can propose changes to the model. These change requests ensure a repeated cycle through the phases until the change is processed into the model and the model is finally complete (Turetken & Demirors, 2007). An example of a Plural model is shown in figure 4.

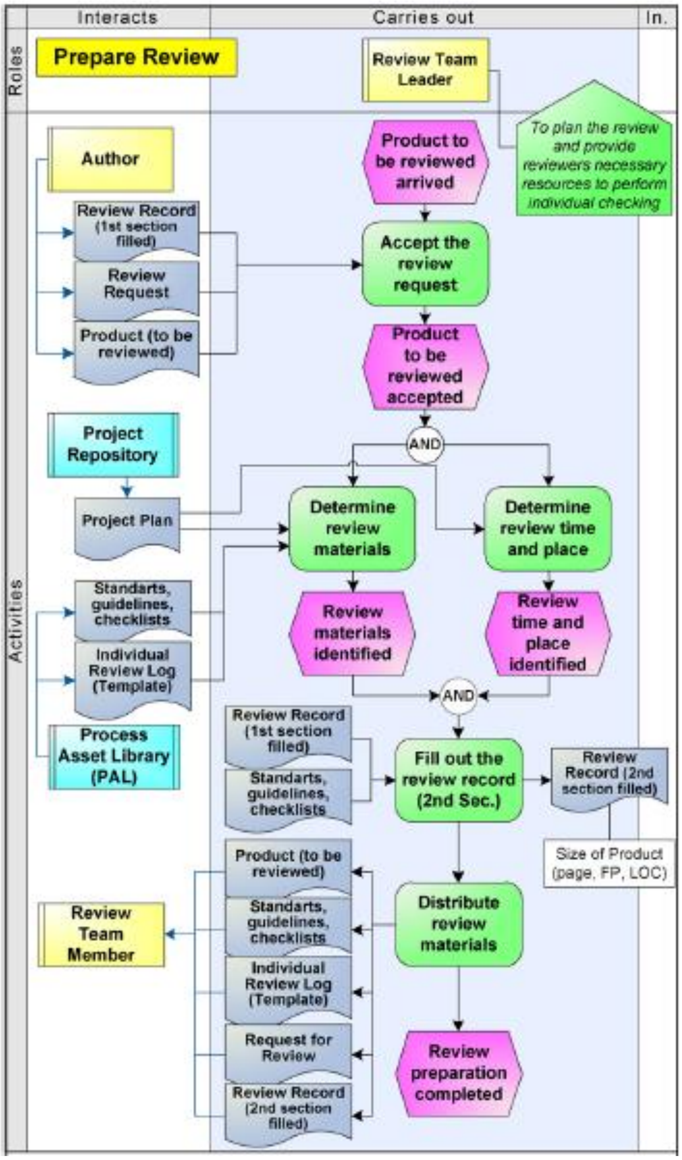


Figure 8: Example Plural model

Turetken & Demirors (2013) performed a case-study to test the method in practice. The result of this case-study that was performed at three different companies, indicating that using this method is highly beneficial as total duration for the cases was minimal (Turetken & Demirors, 2013). Although this new method has already been validated, there has not yet been an extensive study into resulting models derived from applying the method, which is in contrast to classical business process modeling, which has been used throughout different organizations. Also the Plural way of modeling is highly dependend on the modeling skills of the process owners. Another limitation of this method is that the agents have to reach consensus when comparing their processes, especially the use of semantics and the level of detail.

The Plural method has already been applied in small companies, but with employees already familiar with process modeling. Also the classical way of modeling has been extensively researched, but the research was mostly conducted with students, rather than employees at companies (Moody, 2005).

Typically the technique was tested to model the processes and not the outcome of the technique, the model itself.

2.3 Techniques for evaluating process models

With the background of the different modeling techniques in mind a search for literature was needed for the comparison and evaluation of the process models created using the techniques. Siau & Rossi (1998) make a distinction between empirical and non-empirical evaluation techniques in the field of information modeling methods. Non-empirical evaluation techniques consist of seven different ways:

- Feature comparison
- Meta modeling
- Metrics approach
- Paradigmatic analysis
- Contingency identification
- Ontological evaluation
- Approaches based on cognitive psychology

Empirical evaluation techniques consist of five different ways:

- Survey
- Laboratory experiment
- Field experiment
- Case study
- Action Research

According to the authors none of these evaluation techniques can be defined as best one in class. It depends on the situation, environment and other indicators which one can be used at which time. However, Moody (2005) argues that a lack of empirical testing is one of the weaknesses identified in the existing research. Empirical testing is important from both a research and practical point of view. As a research viewpoint it is important, because empirical testing is a key issue in the validation of research ideas. Seen from a practical point of view, empirical testing ensures the evaluation of the practical efficacy of different proposals (Moody, 2005).

2.3.1 Examples of non-empirical evaluation techniques

The use of metrics is an option to compare different process models. Metrics for process models have been extensively described in Mendling J. (2008), Ghani, Wei, Muketha, & Wen (2008) and Rossi & Brinkkemper (1996). Ghani, Wei, Muketha, & Wen (2008) discuss metrics for understandability and maintainability to measure the complexity of models. They furthermore elaborate on different approaches for deriving metrics, such as the Goal-Attribute-Measure (GAM), the Balanced Scorecard (BSC) and the Goal-Question-Metric (GQM) which is used most widely. They did not validate any of these approaches though.

Mendling, Reijers, & Cardoso (2007) discuss metrics that determine whether a process model is understandable. In total 23 factors were examined, factors such as DENSITY and #OR JOINS, on their impact on understandability. This was done using a questionnaire among 73 students from various universities. The questionnaire contained 24 process models to measure the following variable: Theory, practice, perceived, score and ranking. The authors validated their research by interviewing 12 professional modelers. The results from the study indicated that DENSITY and AVERAGE CONNECTOR DEGREE are the most influential variables on understandability. Furthermore, the authors argue that model size as well as the amount of theoretical knowledge is related to the understandability of process models, although these findings are not as strong as the two variables discussed previously.

Mendling (2008) discusses the verification of EPC soundness as a correctness criterion. A set of 15 metrics related to size and 13 metrics that are related to the structure and state space of the process model to measure error prediction is presented as well. They furthermore validated the metrics for a large set of EPC models from practice with the use of statistical models.

2.3.2 Examples of empirical evaluation techniques

Reijers & Mendling (2008) used a laboratory experiment to test whether a modular design of business processes is better understandable than a flattened version. The participants in the experiment were experienced consultants and were randomly divided into two groups. To each group a process with modularity and a different process without modularity was displayed. These processes were derived from a real world situation. The authors then analyzed the amount of correct answers the participants had given to the questions and processed them in a software package. Although the results of the two different processes did not match, the authors could conclude that modularity in a process model appears to improve the understandability of the model.

Another comparison study was performed by Garcia (2011) who used a survey and performed an analysis of practitioner's case studies. The survey was conducted to measure the perceived ease of use and perceived usefulness of conceptual modeling techniques using a Likert scale. The participants consisted of master students, who are already familiar in the field, and process modeling professionals. Although the study focuses on evaluating the modeling itself and not the actual resulting model, the technique that has been used to compare them could be used as an addition for evaluating models that have already been created.

A similar study has been performed by Claes et al. (2012) and focus' on the process of process modeling and its quality, more specifically, the modelers structured modeling style, the frequency of moving existing objects and the modeling speed. The researchers first conducted three small-scale experiments to derive insights in the modeling process. The 40 modelers who participated were asked to model a process based on an informal description. During the experiment the modelers were observed to gain insights in the numbers of elements they created, the time they took to create their model and the amount of objects that were moved. The information resulting from this experiment was used to serve as a basis for the next experiment to test the three defined conjectures. For this experiment the authors used a Cheetah Experimental Platform, which is designed for investigating the process of modeling in a systematic manner. The participants consisted of 103 students following a graduate course on Business Process management at Eindhoven University of Technology. They were asked to model a process in

BPMN which was monitored during class. The collected data was processed in boxplots to derive conclusions.

The study by Recker & Rosemann (2010), who performed an empirical study, examines the user acceptance of process modeling grammars. An instrument development procedural model was developed which consists of five stages, using relevant domain literature, an expert panel, a practioner panel and a field survey. In stage two and three, they used a selected panel of sixteen members with different levels of expertise to conduct a field study. In stage four an index card sorting test was used to improve validity and reliability. Before administering the field study the authors ran a pre-test and a pilot test to test the survey in stage five. The pre-test was conducted with four academics who were familiar with the material. After changes were made to the survey the measurement instrument was pilot tested. The authors used 41 post-graduate students with knowledge in the field and the results were used to make a final revision to the measurement instrument. To conduct the field test the authors created a web-based survey instrument. The sample consisted of respondents that were found via practitioner forums and online groups. The authors used LISREL to process and analyse all data retrieved from the field study.

It must be noted that most experiments conducted so far used students as participants (Moody, 2005), although the study done by Reijers & Mendling (2008) showed that other participants can be used as well. This issue creates problems with the generalizability of the experiment and must be taken into account when performing such an experiment (Moody, 2005).

2.4 Conclusion

This chapter discussed classical business process modeling and subject-oriented business process modeling. In order to compare the process models, which can be created using these modeling techniques, section 2.3 showed that different techniques can be used. For the purpose of this study both an empirical as a non-empirical technique will be used. Empirical testing is a key issue in the validation of research ideas and ensures the evaluation of research ideas. For the purpose of this research a survey is selected as an objective measure to gather data on attitudes and impressions. From a non-empirical point of view the metrics approach is selected.

3 Design of the process models

This chapter elaborates on the design of the process models. The models are designed using the theoretical background that has been discussed in the previous chapter. Furthermore the models are created using the guidelines of modeling, which is explained in this chapter along with the models themselves.

3.1 Guidelines of business process modeling

Process models are subject to various factors that influence the quality of the model. Models become increasingly complex and other factors, like the experience of the designer, should be eliminated to reduce the danger of defective integration (Schuette & Rotthowe, 1998). Therefore, a framework is created called "Guidelines of business process modeling" to structure factors for the evaluation of process models (Becker, Rosemann, & Uthmann, 2000). According to the authors the guidelines aim at developing specific design recommendations in order to enhance the quality of models.

The guidelines presented in these articles are however very abstract and therefore not very useful to practitioners. Mendling, Reijers, & Van der Aalst (2010) propose a set of seven guidelines (7PMG) that are very concrete and more detailed, this way the guidelines can be used in practice much easier:

1. Use as few elements in the model as possible. A larger model tends to be less understandable and is more sensitive to errors.
2. Minimize the routing paths per elements. An increase in the number of input and output arcs influences the readability of the model in a negative way.
3. Use one start and one end event. It becomes more difficult to understand a model when a model has multiple start and end events, this should be avoided.
4. Model as structured as possible. A structured model is better readable to the user which makes it better understandable.
5. Avoid OR routing elements. These elements tend to create a higher error rate and should therefore be avoided.
6. Use verb-object activity labels. According to the authors, verb-object style is more useful than action-noun labels or other type of styles.
7. Decompose the model if it has more than 50 elements. As a guideline a model should not contain more than 50 elements for the same reasons as proposed by guideline 1.

In order to create an optimal process model, a combination of the more abstract guidelines and the concrete guidelines is necessary. But using these modeling guidelines does not necessarily result in a high quality model. Therefore, the quality of the model is also an important aspect of the process modeling domain.

3.2 Modeling quality

The quality of a business process model is very important. There are three main reasons why model quality is important (Reijers, Mendling, & Recker, 2010). First, it cannot be assumed that all practitioners have the same modeling capacity. They differ in the amount of training they had and in experience.

Secondly, the error rates of process models are relatively high which indicates a poor model quality. Finally, the cost of errors increases over the development of the model. Correcting an error during post-implementation is more costly than fixing it during a previous stage (Moody, 2005). Therefore, the quality has to be checked during different stages in the modeling process. It is important to know which aspects of the quality of models needs to be taken into account. According to Bridgeland & Zahavi (2009) process model quality consists of three aspects, model fidelity, model verification and model validation. Reijers, Mendling, & Recker (2010) extend this view with quality certification.

3.2.1 Model fidelity

A process model is created to visualize the process that is being examined. Of course the model should closely match the process in the real world. This is called the model fidelity, the higher the fidelity, the better the model matches the real world (Bridgeland & Zahavi, 2009). This does not necessarily indicate that a high-fidelity model is always better than a low-fidelity model. High-fidelity models are usually much more detailed and therefore less readable and understandable to the user. They are more difficult to maintain as well due to the high level of detail, this indicates that changes are difficult to implement. Therefore, a tradeoff has to be made on the desired level of fidelity of the model.

3.2.2 Model verification, validation and certification

Model verification, validation and certification have been incorporated into a framework that has been developed by Reijers, Mendling, & Recker (2010) and is based on the study on quality in conceptual models by Lindland, Sindre, & Solvberg (1994) and further explained in the study by Kühne, Kern, Gruhn, & Laue (2010). The framework that the authors developed consists of three quality goals:

- Syntactic quality
- Semantic quality
- Pragmatic quality

Syntactic quality involves the extent to which a model complies with the syntactical rules of the modeling language. Suppose a model is captured as an EPC, it would be syntactically wrong to connect two events. These rules are usually described in the theory of the used modeling technique. Without syntactical correctness, semantic and pragmatic quality are no longer relevant. Syntactic quality is subject to verification. Verification checks the properties of the model independently of the real-world situation and consists of two elements, static properties and behavioral properties. Static properties involve the types of elements that are used and the way they are connected with each other. Behavioral properties are about the correctness or soundness (in case of workflow nets) of the model (Reijers, Mendling, & Recker, 2010).

Semantic quality relates to model fidelity, but is more detailed. The model aims at approximating the real world. This involves both validity and completeness. Validity is about the statements that are made in the model, these have to be correct. The other goal is completeness which means that the model consists of all the statements that are correct and relevant (Lindland, Sindre, & Solvberg, 1994). Semantic quality is subject to validation. In order to validate a model a certain technique has to be used. Reijers, Mendling, & Recker (2010) propose two different techniques, simulation and paraphrazation. When a process is simulated users are confronted with the behavior of the model in an intuitive way. This makes it easier for them to compare the model with the real world. Paraphrazation uses a different approach. This technique follows the process in reverse, in such a way that the model is explained in natural language. This is especially useful for people that are not familiar with process modeling.

Pragmatic quality relates to the alternatives for expressing the same meaning. The model should be perfectly understandable in the sense that the relations between the elements should be very clear. As part of certification, the goal is that the process owner approves the model when that person is satisfied with the clarity and readability. This results in a usable model by the stakeholders (Reijers, Mendling, & Recker, 2010). Also other approaches to evaluate the quality of models have been proposed, see Moody (2005), Makni, Khlif, Haddar, & Ben-Abdullah (2010) and Schuette & Rotthowe (1998).

3.3 Modeling notation

As has been discussed in chapter 2 of this thesis, the EPC modeling notation has been used to model the different processes. Also the Software package ARIS Business Architect was chosen as a modeling tool. With the software package and modeling language all kinds of symbols are used which are listed in table 2.

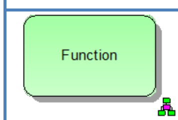
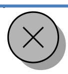
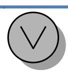
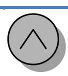
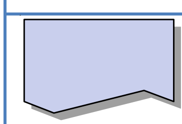
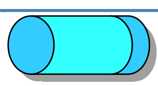
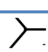
Symbol	Explanation
	Event symbol
	Activity symbol, the symbol on bottom right indicates the existence of a sub process
	XOR-split, only one out of 2 or more options must be executed
	OR-split, one or more out of two or more options must be executed
	AND-split, all steps must be executed and occur in parallel
	Document, information carrier that could be an e-mail, Excel file, hardware, etc.
	Database, special software for storage of data
	Connector, links multiple elements to create a process model

Table 2: Symbols used in process models

In order to enhance the readability of the process models the document symbol incorporates more than only a document. It also represents hardware that flows between departments and for example a phone call. This was done, because otherwise a maze of different symbols would occur which would influence the readability of the model to a large extent.

3.4 The designed process models

The verification of the models was done by a modeling expert. A couple of changes had to be made to the models in order to meet the requirements for soundness. Furthermore, the models were validated by an experienced manager (process expert) who is familiar with the process. The input from the validation has led to a small revision of the models as some elements were not modeled correctly. Moreover, specific departments needed to be defined in a different way to avoid confusion. Also some extra documents had to be added to some processes, as they were not incorporated in the models. Some steps might be more important for the user than other steps, so these must be very clear from the model. Therefore, along with the validation of the process model, the supply chain manager was asked for the most important elements and steps within the processes. This information could be used for defining the understandability questions in the questionnaire. The four process models can be found in Appendix D, E, F and G.

3.4.1 RMA process

The Classical RMA process model can be found in Appendix D, the Plural RMA process models can be found in Appendix E. The process starts with the detection of a problem by a customer. The customer contacts the technical supports specialist (TSS), either via phone or via e-mail, who troubleshoots the problem. The TSS checks the status and data of the device of the customer with site admin and Fleet portal which could lead to a solution. In case the problem is solved the process is finished, but when the problem cannot be solved the unit has to be returned and the RMA procedure is started. In both cases a ticket is raised in the CRM system to document all steps that are performed to solve the problem.

The RMA procedure continues with the TSS who checks the warranty of the device using SNUTT. The result is communicated to the customer via an agreement form which incorporates all information concerning the warranty period, cost of replacement and terms and conditions. Subsequently, the customer has multiple options:

- Do not reply; a reminder is send and after a certain amount of time without receiving notice from the customer the RMA is cancelled
- Product inside warranty, but customer disagrees with the agreement form; the agreement form can be adjusted by the TSS to meet customer needs or RMA is cancelled
- Product inside warranty and customer agrees to the agreement form; RMA process continues
- Product outside warranty and customer disagrees with the agreement form; the agreement form can be adjusted by the TSS to meet customer needs or RMA is cancelled
- Product outside warranty and customer agrees to the agreement form; RMA process continues, but adds a separate process at the same time of billing the customer for the spare part price

The RMA process continues by sending the confirmation of the agreement form to the logistics department after which the logistics department sends the order to the 3rd party logistics. At the same time the Hotline administration is notified who deactivates the broken part. The 3rd party logistics then sends the new part to the customer and an outbound file is created which is send to the hotline administration. When the part is received by the customer the part can be replaced and the broken part can be send back to the 3rd party logistics.

In case the broken part is not received within 30 days, a reminder is send to the customer, which gives the customer another 15 days to send back the item. If the item is still not received after 45 days, the customer is billed for a replacement part price. However, when the part is received within the required time, the part is analyzed by the 3rd party logistics and an inbound file is send to the hotline administration. As a result from the analysis the part can be send back to the supplier, can be scrapped, or is refurbished and can be put in stock. The results of the analysis are send to logistics and the RMA is closed in the CRM system.

The logistics department checks the results of the analysis. At the same time the hotline administration processes the in- and outbound file and uploads the files into SNUTT. Also the deactivation of the broken unit is checked. In case the conclusion of the analysis indicates that the damage is caused by the customer and the product was within warranty, the customer is billed for the replacement price. A final check is done to ensure payment of the invoices and consequently the process ends.

3.4.2 Training/installation process

The Classical training process model can be found in Appendix F, the Plural training process models can be found in Appendix G. The process essentially starts with an order from the customer, however, for the purpose of this research, the process starts with setting up the contract by the sales division. The customer subsequently signs the contract after which the contract is archived by the contracts division. At the same time an account manager (AM) is assigned to the customer who receives the contract when it is signed.

An option a customer can select is an extensive training for installing the units themselves. In case the customer selects this option the account manager has to setup a configuration sheet which is shared with the trainer and Logistics. The trainer prepares the training and plans the date together with the customer.

Besides setting up the configuration sheet the AM orders the required parts via Logistics. Logistics then orders the required parts at the 3rd party logistics. They send the ordered products to the customer and at the same time send an outbound file to the hotline administration and Logistics. The hotline administration uploads the outbound file in SNUTT and activates the units that are send to the customer which has to be done before the units are installed at the customer. Logistics is responsible for billing the customer which can be done as soon as the outbound file is received.

The installation can be either done by the customer himself, by an installer or a recognized Service Center. After the installation the process is finished. In case the customer opted for a training the training is performed together with the trainer. Subsequently, the customer can install and test all units on his trucks, after which the process is finished.

3.5 Information systems

Within the RMA and training process multiple information systems are used to support the processes. In both processes the same information systems are used, which results in only one overview. The documents are usually Word or Excel files that are communicated via e-mail or printed and send by the postal service, but can also be the hardware flow of for example a broken part. Besides, several databases are in place to capture information from different processes. Table 3 shows the lists of databases that are used in the RMA and training process.

System	Description
CRM	Customer Relationship Management system, incorporates customer data, but is also used to document RMA's.
Provider portal	Portal from the provider to deactivate SIM cards.
Superman	(De)Activation of the units in trucks.
Fleet portal	Web portal for the customer for fleet management.
Site admin	Administration tool for Fleet portal, used for account creation, provisioning and (de)activation of options.
SNUTT	Abbreviation for Serial NUmber Tracking Tool. Is used by TSS for warranty checks.
Exact	Administration and accounting tool used for registering and invoicing customers.

Table 3: Used information systems

These databases have been mapped in the process models which were discussed in the previous sections.

4 Non-empirical evaluation of the process models

In order to compare the process models an empirical as well as a non-empirical research was performed. This chapter elaborates on the non-empirical evaluation and consists of the metrics approach on the business process models to indicate the understandability of the two models from a non-empirical perspective. First, the metrics that were used are explained. Next the metrics are applied to the process models after which conclusions are drawn from the results.

4.1 Business process model metrics

In literature already a lot of metrics have been investigated that are related to the understandability of process models. However, only a couple of them are proven to be related to the understandability of process models. Both Mendling, Reijers, & Cardoso (2007) and Vanderfeesten, Reijers, Mendling, Aalst, & Jorge (2008) confirmed the density metric as well as the average connector degree to be significantly correlated to the understandability of process models. Also model size is mentioned to be of influence, although this is based on researchers' perception. Therefore, in addition to the simple count metrics to give an indication of the model size, for the purpose of this research, the density metric and average connector degree were computed to judge both models on their understandability and were derived from Mendling (2007).

Because the Plural models also use the EPC modeling language, the metrics can be used to measure the understandability of Plural models as well. Due to the hierarchy of the Plural models an attempt is made to compare the models on the metrics when the Plural model is completely unfolded. This way also all the sub processes are involved as they too are necessary to fully understand the process model. Furthermore, in both the classical and the Plural models the databases and documents that are involved in the processes are left out of scope for the calculation of the metrics. These are difficult to compare, because in the Plural model the documents are the connection between two operations while in the Classical model it functions as an output document for one operation and the same document as an input document for the other operation, which means two documents are modeled.

4.1.1 Size metrics

In order to determine the size of a process model, different variables are of influence. A process model consists of nodes, tasks, arcs, splits and joins. The guidelines of process modeling discussed in chapter 3 showed that a large process model is less understandable than a small process model. Also the amount of splits and joins should be minimized to enhance understandability. Therefore the amount of nodes, tasks, arcs, splits and joins are determined to give an impression of the model size.

4.1.2 Density metric

The density of a process model gives the ratio of the number of arcs divided by the maximum number of arcs. A business process model with a high density is less understandable than a process model with a low density (Mendling J. , 2007). In other words, the lower the density the better, although one should be careful with interpreting this value as comparing two models with a different number of nodes influences the density substantially.

In order to compute the density of an EPC process model syntactical constraints have to be considered. The three main constraints mentioned by Mendling (2006) that are discussed here are part of a larger set of constraints mentioned in Nüttgens & Rump (2002):

- Minimal EPC: The general rule of an EPC, an EPC must have at least one start event, one end event and one function
- Cardinality: Each function has one input and one output, each event has at most one input and one output and connectors have either one-to-many (splits) or many-to-one (joins) input-output cardinality.
- Coherence: An EPC is a coherent graph.

As all the process models match the constraints the density metric can be used in order to indicate the level of understandability of the process models. The formula for the variable density:

$$\Delta(G) = \frac{|A|}{|N| \cdot (|N| - 1)}$$

Where,
$G = Model\ type$
$A = Set\ of\ arcs$
$N = Set\ of\ nodes$

The formula gives the total amount of arcs divided by the maximum number of arcs, computed by the total amount of nodes times the amount of nodes minus one.

4.1.3 Average connector degree metric

The average connector degree calculates the amount of nodes a connector is in average connected to. Likewise the density metric, a business process model with a high degree of connectors is likely to be less understandable than a process model with a low degree of connectors. The average connector degree is computed via the following formula:

$$\overline{d_C}(G) = \frac{1}{|C|} \sum_{c \in C} d(c)$$

Where,
$G = Model\ type$
$C = Set\ of\ connectors$
$d = The\ amount\ of\ arcs\ a\ connector\ is\ connected\ with$

The formula gives the summation of the amount of arcs that are connected to a connector divided by the total amount of connectors that have been modeled in the process model.

4.2 Results

In table 4 the characteristics of each model are summarized. The first nine rows provide the following properties: number of nodes, number of arcs, number of tasks and the amount of AND-, XOR-, and OR-split and –joins, the average connector degree and the density. Between the brackets at the RMA Plural and Training plural model are the number of nodes and arcs mentioned that occur in the initial model without the underlying sub processes.

Metric Model	RMA Classical	RMA PLURAL	Training Classical	Training PLURAL
#NODES	62	128 (70)	47	70 (45)
#ARCS	103	165 (103)	53	85 (58)
#TASKS	25	30	17	26
#AND-splits	4	0	2	0
#AND-joins	4	0	2	0
#XOR-splits	9	10	1	1
#XOR-joins	8	2	1	1
#OR-splits	0	1	2	1
#OR-joins	0	0	2	1
Average connector degree	3,27	3,44	3,40	3,50
Density	0,027	0,010 (0,021)	0,025	0,018 (0,029)

Table 4: Metrics from non-empirical research

The number of nodes, arcs and tasks clearly shows a substantial difference between the RMA models and the training models. However, when the classical model is compared to the non-unfolded Plural model the difference is much smaller. It is therefore interesting how this result relates to the understandability of the process models as model size is also related to this factor and size is almost equal among the non-unfolded Plural model and classical model. On the basis of these metrics it is expected that the Plural model might be more difficult to understand than the classical model.

Another interesting fact is the absence of AND-splits and AND–joins in the Plural model. This can be explained by the way the operations in the Plural models are connected. The operations are connected via the document flows and as such, in case multiple events should happen at the same time, the document flows to multiple operations, hence the absence of the AND-splits and AND-joins.

Furthermore, an interesting aspect is the relation between the number of XOR-splits and XOR-joins in especially the RMA model. Apparently, the Plural model lacks XOR-joins when the amount of XOR-splits is taken into account, where in the classical model they are more or less equal. Although this seems weird as one would expect that every XOR-splits eventually ends up with an XOR-join, it is actually easy to explain when looking at the way a Plural model is modeled. The Plural model consists of operations performed by their actors. The end of an operation can be modeled in several ways, one of which is an exclusive choice (XOR-split) in events. These events already indicate what happens, for example "Adjusted agreement form" refers to the associated document "Adjusted agreement form". So although an operation might have different output documents, the XOR-split determines which one is executed. It is therefore not necessary to model an XOR-join, it is namely the end of the operation. This might only happen in case of sub-processes where an operation is explained in more detail and the operation is not finished yet, which is for example the case in the training plural model, hence the equal amount of XOR-splits and XOR-joins. This same explanation also applies for the amount of OR-splits and OR-joins.

The average connector degree shows just a small difference between the models, so serves only as an indication. Apparently, the RMA classical model seems to score higher on understandability (3.27) than the RMA plural model (3.44), although not significantly. The same result can be seen between the training classical model (3.40) and the training plural model (3.50). This indicates that the models are relatively the same in terms of understandability. However, remarkable is the fact that when the RMA models are compared with the training models, the RMA models seem to be better understandable than the training models, this in contrast to what one would expect from their size. Apparently the RMA models have a better ratio between the amount of arcs and connectors, although the figures do not differ substantially.

The last metric discussed in table 4 is the density metric. Although the density of the RMA and training plural model are better than the RMA and training classical model, it must be noted that this is just an indication as the two models differ in size and the differences are relatively small. This is clearly shown when the non-unfolded metric of the density is computed. In that case the density of the Plural models becomes worse, although for the RMA model it is still in favor of the Plural model. With the same amount of arcs, the classical model has fewer nodes than the Plural model, leading to a slightly better density score.

4.3 Conclusion

Summarized from the metrics that have been discussed, it is clear that metrics alone do not provide enough information to determine how understandable the process models are, especially due to the non-significant differences between the metrics. On the basis of the #nodes, #arcs and #tasks metrics it is expected that the Plural model might be more difficult to understand than the classical model. This is confirmed by the average connector degree metric which shows that the classical model scores slightly better than the Plural model. The density metric, however, contradicts to these metrics, but this can be explained due to the different sizes of the models which makes comparison of this metric fairly difficult. Therefore, in addition to the non-empirical research, an empirical study was performed to further investigate the difference between the classical and plural models.

5 Empirical evaluation of the process models

Besides the non-empirical research, that did not provide enough information to determine the understandability of the process models, an empirical study has been conducted. First, the set-up of the experiment is discussed after which the design of the survey (Appendix E) is explained. Section 5.3 elaborates on the selection of participants after which the survey procedure is discussed. Section 5.5 discusses the hypothetical relations between certain factors and understandability. This leads to the final section where the results of the questionnaire are discussed.

5.1 Set-up of the experiment

The empirical research consists, as mentioned before, of a survey. The survey was conducted among the employees at the company. A distinction can be made between the employees that are part of the RMA and/or training process and employees that do not have a relation with these processes. This led to a better comparison of the understandability of the models due to the differentiation of the sample. The participants were randomly divided into two groups according to table 5.

	RMA model (model 1)	Training model (model 2)
Group 1	Classical	Plural
Group 2	Plural	Classical

Table 5: Allocation of the groups to the models

Each participant was shown two process models, one model about the RMA process and the other model about the Installation/training process. Furthermore both models were different in setup, being one model modeled by the plural modeling technique and the other one by the classical modeling technique. To further strengthen the research half of group 1 started with the classical model and the other half with the Plural model. The same principle was applied to the second group of respondents. It must be noted that for preventing bias of the outcome of the survey, the persons who were involved in the verification and validation process were not consulted for the questionnaire.

5.2 Design of the survey

Because the purpose of this research is the comparison of two models, modeled with different approaches, information is needed on attitudes, opinions, impressions and beliefs of human subjects; a survey is therefore selected for the empirical approach. The questionnaire (Appendix H) was designed in order to measure the understandability of the models and also the opinions from the participants. The survey started with an introduction of the subject, where the participants were informed about the scope of the research. Next, the survey consisted of three parts of which part 2 and 3 were asked twice, once for each model:

1) Part I: The first part of the questionnaire consisted of demographical questions like age, position in the company, working years, etc. These questions were aimed at controlling the results.
2) Part II: The second part aimed to elicit the understandability of the process models. This part consisted of six questions per process model which were formulated using three different

perspectives (two questions per perspective) defined by Aalst (2000) and were formulated similarly to Mendling, Reijers, & Cardoso (2007):

1) The process perspective
2) The organizational perspective
3) The information perspective

The process perspective specifies which tasks need to be executed and in what order. The organizational perspective describes the relationship between different roles or departments. The information perspective involves the information flow, such as documents that travel between different roles. Two questions on each of the perspectives were prepared. The answers to these questions resulted in a SCORE variable calculated as the sum of correct answers. This SCORE variable measured the effectiveness of understanding the process model.

3) Part III: After the understandability questions, questions were asked about the perception of the participants on the models. This started with a question of the perceived difficulty of the models from Mendling, Reijers, & Cardoso (2007). The theory by Moody (2003) and Seddon & Yip (1992) was used to design the other perception based questions of the questionnaire. The theory of Moody implies that the questions need to be divided into three perception based variables to evaluate the methods:
    1) Perceived ease of use (PEOU)
    2) Perceived usefulness (PU)
    3) Intention to use (ITU)

    As the questions on ITU were very limited in an attempt to translate them for this research purpose they were complemented with questions from Recker & Rosemann (2010) which were validated in Maes, Poels, Gailly, & Paemeleire (2005). The questionnaire was completed with four questions from Seddon & Yip (1992) measuring user information satisfaction (UIS) in terms of adequateness, efficiency, effectiveness and satisfaction.

In order to ensure balance of the questions, the questions were arranged in a random order to reduce the potential ceiling effect that could lead to monotonous responses (HU & Chau, 1999). Simple yes/no questions were used, but also questions were formulated using a Likert scale. The complete questionnaire can be found in Appendix H.

5.3 Selection of participants

An attempt was made to create a selection of potential participants for this research. As the company is relatively small with approximately 60 employees and a substantial amount of them is involved in one of both processes a decision had to be made on whom to invite for taking part in the research. Therefore, a random selection of managers and employees was made that were available and an attempt was made to incorporate both involved and non-involved participants. This led to the following selection of employees: Project managers, technical support specialists, IT engineers, HR representatives, administration, staff members and board members. With respect to the available time of the participants and the research a total of 21 respondents participated in this study

5.4 Survey procedure

In order to enhance the accessibility, the survey was provided via the website www.thesistools.nl. The use of a digital questionnaire has several advantages over paper-based surveys. According to Hayslett & Wildemuth (2004) and Greenlaw & Brown-Welty (2009) web administration of surveys is beneficial in terms of administration time, costs and they are directly returned as well. Also, the two models that had to be judged by the participants were displayed digitally. Although this is not optimal for the visibility of the process models as they are not visible at one instance, so scrolling through the model is necessary, it was needed due to the hierarchical setup of the Plural model. Furthermore, the models were too large to print on for example A3 paper size and extra slides had to be printed for the sub processes of the Plural models, which do not enhance the usability. Furthermore, the use of a beamer to enlarge the visual process was tested, but did not enhance the visibility due to the relatively low resolution.

So the experimental setup can be described the following way: The participant had two screens available, on one screen the process model and the other screen the questionnaire. The researcher sat alongside the participant to measure the time the participants needed on the questions about understandability and as a method to enhance the quality of the responses of the participants. The time was started at the moment the participant arrived at the question about understandability and ended as soon as the answer was given. Also the researcher made sure that prior to the start of the questionnaire the participants were aware that the process models might be modeled differently than how the process functions in practice. This was done in order to avoid the participants answering the questions according to their knowledge about the process instead of using the models to answer the questions. Furthermore the location of the experiment was outside the participants' office so they would not be distracted by their work.

A pre-test was conducted for the first version of the questionnaire, which led to reformulation of a couple of questions. Also the links from certain questions in the questionnaire to the process models were revised in order to make it more clear and understandable, so misinterpretation could be avoided. Some minor changes were made to the process models to improve the relation to the questions as well.

5.5 Hypothetical relations between factors and understandability

This section elaborates on the hypothesized relations between the factors on understandability. The metrics already showed a slight difference between the models, indicating a beneficial outcome for the classical model. This forms the basis of the hypothetical relations between the defined variables.

It is expected that the classical model takes less time to answer the questions on understandability. This is assumed, because classical models are already widely used and therefore recognizable to the participants. However, the learning effect is suspected to be stronger for the Plural model. Once participants figure out how to use the model, it is expected that this positively influences the amount of time spent on each question and it's score. Furthermore there is no hierarchy involved which should also benefit the classical models.

H1: The amount of time participants spend on the understandability questions takes less time for the classical models than for the Plural models.

Besides the amount of time a participant takes to answer the questions, also the SCORE for the classical models is expected to be higher for the classical models than the Plural models for the same reasons as mentioned before.

H2: The classical models are more positively related to the SCORE of the understandability questions than the Plural models.

Furthermore, it is hypothesized that the perceived factors are in favor of the classical models. This indicates a lower score on the perceived difficulty and higher scores on the perceived intention to use (ITU), perceived usefulness (PU), perceived ease of use (PEOU) and perceived information user satisfaction (IUS).

H3: The classical models score higher on the perceived factors than the Plural models.

Another aspect which is important is the relation between the factors and understandability. It is expected that the perceived difficulty is negatively related with the SCORE and also the amount of TIME. The same is expected for the perceived factors and SCORE. Furthermore, an association can be made between the calculated metrics and SCORE. The average connector degree should be negatively related to SCORE. The same expectation is there for the density metric. A higher score on the average connector degree or density metric should lead to a lower SCORE value.

5.6 Results

The results of the empirical study were processed using SPSS statistical software. In total 21 employees (N=21) participated in this study who all filled in the questionnaire accompanied by the researcher. The average age of the employees was 37.29 years (SD = 8.78) and most of the participants were men (66.7%). The average working years of the sample was 5,38 years and average years in their position yielded 3,34 years, see for a complete overview appendix F.

Before starting the analysis of the data from the questionnaire, at first the data is checked on outliers and other abnormalities. The boxplot on the variable totaltimeQ11[3] seem to have an extreme value. Although this value seems to be an outlier, it was not removed due to the relatively small sample size. It was also checked on its feasibility and this outlier is not the result of mistyping or a wrong measurement so it remained in the sample data. Furthermore extreme values in the individual time variables remained in the sample data for the same reasons mentioned above. The data check revealed another issue due to missing values. These values were defined in SPSS as missing values.

[3] The TotaltimeQ11 variable indicates the summation per participant of question 11a through question 11f

In order to compare two groups of participants on various variables different tests can be performed. An independent t-test and an ANOVA can be used to test whether two group of means are different. Although these tests seem to be legitimate in this case, they do require certain assumptions, before the tests can be conducted. The following assumptions are specified for the independent samples t-test and ANOVA:

1. Independence of observation: the participants are not systematically linked, so independent from each other.
2. Normality: The sampling distribution is normally distributed
3. Homogeneity of variance: the variances of the population are more or less equal

1. The first assumption is met, because the participants were completely random and also randomly divided into two groups.
2. The results of the test on normality show whether the sample data is normally distributed. This can be done with the Kolmogorov-Smirnov test. If this test turns out to be significant the data is not normally distributed. In case the data is not normally distributed neither the t-test nor the ANOVA can be used for comparing two groups of means for this research. In these cases a non-parametric test has to be performed, called the Mann-Whitney test. This test is pretty similar to the t-test, however it makes fewer assumptions about the type of data that can be used. It thus depends on the data of the test, which test is being used.

   The T-test is reported the following way: M = Mean, SE = Standard Error and *t*( ) indicating a t-test with the degrees of freedom followed by the value of the test statistic, then the level of significance is reported ($p < 0.05$, ns = non-significant) and the effect size (*r*).

   The Mann-Whitney test which compares the medians is reported as follows: U, which gives the test statistic, *z* gives the z-score, p the level of significance and *r* the effect size.
3. The homogeneity of variance can be checked with Levene's test. A significant Levene's test ($p < 0.05$) indicates a violation of the assumption. This results in a T-test to look for the row labeled Equal variances not assumed.

Three different variables are of particular interest for this study, the total time it took for a participant to complete the questions on understandability in the questionnaire per model, the score of the participant per model (the total number of correct answers) and the total subjective score per model. There might be certain relationships between these variables and therefore the different relationships were measured. This was done using bivariate correlation.

The results indicate that there is no correlation between these variables. However, correlations were found among the subjective variables and a correlation could be found between the total years an employee works at the company and the total correct amount of answers for every model except the Classical RMA model, see table 6 ($p < 0.05$). Spearman's rho was used, because the data was not normally distributed. Apparently, the number of working years does not have a relation with the RMA model, modeled in the classical way (0.246).

		Correct answers			
		RMA Classical	RMA Plural	Training classical	Training Plural
Spearman's rho	Correlation coefficient	0,382	0,823	0,676	0,764
Working years	Sig. (2-tailed)	0,246	0,003	0,032	0,006
	N	11	10	10	11

Table 6: Correlation working years and correct answers

In addition to the correlations between the variables the mean of the variables perceived difficulty, SCORE, TIME, ITU, PU, PEOU, UIS and satisfaction were computed and added to table 4 which results in table 7. The results of these variables give already a first impression of the differences between the models. As expected the mean perceived difficulty tends to be lower for the classical models than for the plural models and in addition the training models seem to be less difficult than the RMA models. Furthermore, the SCORE among all models is relatively high, considering the maximum score of 6 correct answers out of 6 questions. Still, there is a difference visible indicating an higher SCORE for both classical models than their Plural counterparts. In order to further examine the SCORE across the models, the Mann-Whitney test was applied, as the assumption of normality was violated. The Mann-Whitney test indicated that SCORE on Model 1 Classical (Mdn =5.00) did not differ significantly from Model 1 Plural (Mdn = 4.00, U = 49.0 , ns, z = - 0.437) as does SCORE on model 2 Classical (Mdn = 5.00) from model 2 Plural (Mdn 5.00, U = 53.5 , ns, z = - 0.115).

The same results were derived from the tests on Perceived difficulty, TIME, PU and PEOU, however ITU and Satisfaction seem to differ significantly on model 1. The Mann-Whitney test indicated that ITU on the RMA model Classical (Mdn = 9.0) was significantly lower than on the RMA model Plural (Mdn = 12.0) U = 19.50, z = - 2.347, $p < 0.05$. As few significant levels were derived from the tests (actually only on model 1 ITU), a closer look was taken on the individual level of the variables. This resulted in a significantly different satisfaction level for the RMA model. Again the Main-Whitney test suggests that Satisfaction on the RMA model Classical (Mdn = 3.00) is significantly lower than on the RMA model Plural (Mdn = 4.00) U = 23.00, z = -2.407, $p < 0.05$.

Metric Model	RMA Classical	RMA PLURAL	Training Classical	Training PLURAL
#NODES	62	128 (70)	47	70 (45)
#ARCS	103	165 (103)	53	85 (58)
#TASKS	25	30	17	26
#AND-splits	4	0	2	0
#AND-joins	4	0	2	0
#XOR-splits	9	10	1	1
#XOR-joins	8	2	1	1
#OR-splits	0	1	2	1
#OR-joins	0	0	2	1
Average connector degree	3,27	3,44	3,40	3,50
Density	0,027	0,010	0,025	0,018
Mean perceived difficulty	3,0	3,3	2,5	3,0
Mean SCORE	4,36	4,2	4,8	4,45
Mean TIME	499,00	636,80	476,90	442,73
Mean ITU (M1 sig.)	8,80	11,20	11,60	10,20
Mean PU	14,64	17,50	18,20	16,64
Mean PEOU	16,09	18,70	17,91	20,70
Mean Satisfaction (M1 sig.)	2,91	4,00	3,90	3,55

Table 7: Metrics complemented with empirical research

Although no statically significant differences could be discovered among the other variables (only on time variable 11D, which is discussed later), does not mean, that there is no difference at all. Let's first discuss the RMA model in both ways. Apparently, for the RMA model it takes more time on average to answer the six questions for the Plural model than for the Classical model, which corresponds to the perceived difficulty level. Although the participants took more time, their SCORE was nonetheless lower. Remarkable are however the scores on the perceived questions. All five mentioned variables (ITU, PU, PEOU, UIS and satisfaction) tend to be higher for the Plural model than for the Classical model. So although the Plural model is perceived more difficult, takes more time and has a lower score, participants favor the modeling principle for its intention to use, perceived usefulness, perceived ease of use and find it more satisfactory, even when the understandability is lower in terms of metrics like average connector degree and the number of nodes.

Let's discuss the training model in order to see whether these results are similar to the RMA model. The classical model seems to take more time on average than the Plural model, but at the same time the participants' SCORE is higher. Moreover, the classical model was found to be less difficult, which seems consistent with the score and the metrics variables average connector degree and #NODES. The perceived variables are however less convincing. Although ITU, PU, UIS and satisfaction are higher for the classical model, PEOU is not. This is a remarkable result considering also the other variables.

These results of the training model seem to contradict to the results from the RMA model. The results from the RMA model clearly indicate that the Plural model is preferred over the Classical model in terms of the perceived variables. However, the opposite is visible at the training model, where the classical model is preferred over the plural model which is also confirmed by the SCORE, perceived difficulty and metric variables. In order to explain this result, a closer look is necessary at the relationship between the mean time and score of both models. It could be the case that there is a learning effect present, which could be stronger for one modeling technique. This learning effect would be visible by a declining trend line indicating that the last questions take less time to answer than the first questions.

Therefore in Figure 7 and figure 8 the score on each question (in percentage, 100% is all participants answered the question correctly) is showed in relation to the mean time it took to answer the question and the potential learning effect (Linear trend line). Let's first discuss the RMA model. Apparently both modeling techniques have more or less the same learning effect in the RMA model. However, as shown before in table 7 it can be seen that on average the Plural technique does take more time to answer the questions than the classical technique, although for question 11C it is more or less equal while the SCORE differs substantially on this question, having a higher score for Plural than for classical (no sig.). Furthermore, question 11E seems to be more difficult for both models, but at the same time have a relatively high score.

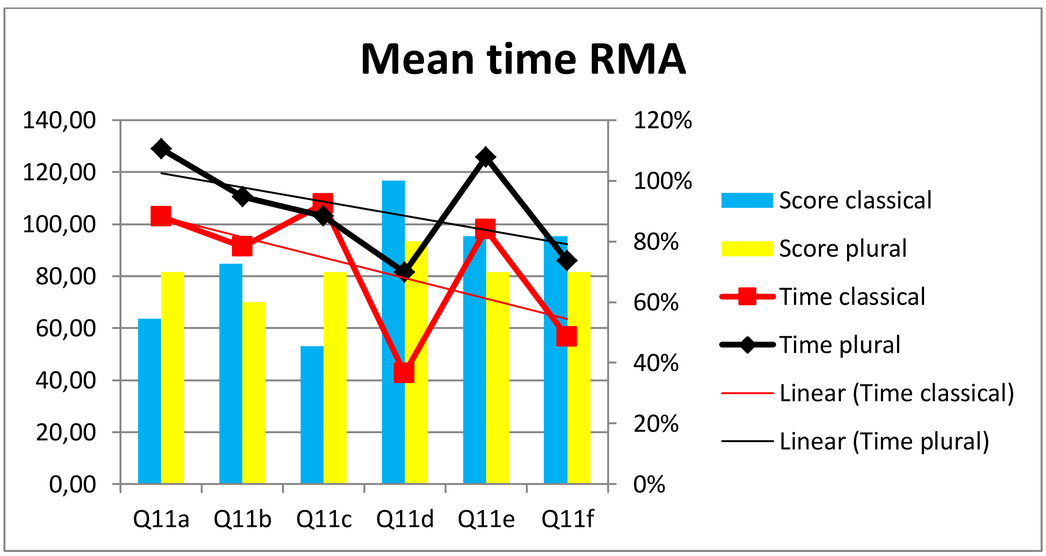


Figure 9: Mean time and mean score RMA model

In addition to the RMA model also the training model is checked the same way. A clear learning effect can be discovered with a stronger learning effect for the Plural model than the classical model. The first question was relatively easy with all participants answering the question correct in a reasonable amount of time. Furthermore, question 20B seems to have been a very difficult question, indicating a high amount of time needed to answer the question in both modeling techniques with only a small percentage of good answers. This can be explained on the one hand by the different OR-/XOR-SPLITS and –JOINS modeled in the Classical model that are involved in this particular process and on the other hand the sub-process modeled in the Plural model, which takes extra time to figure out and makes it harder to understand. Questions 20D and 20F seem to have more or less the same results, but questions C and E differ in the amount of time needed to answer these questions in favor of the Plural model.

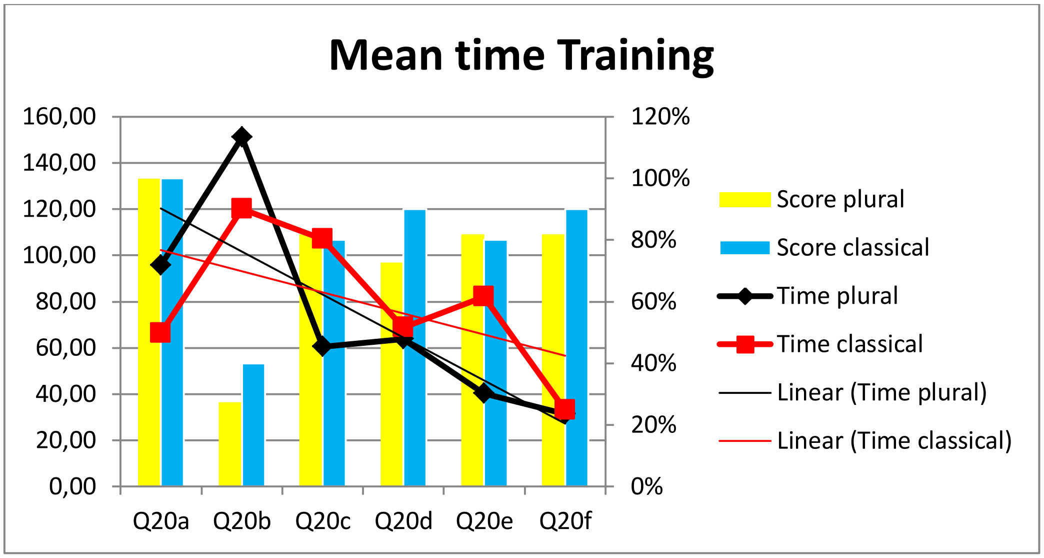


Figure 10: Mean time and mean score training model

All individual variables were checked, meaning every question was tested on differences between the two models. No significant differences were found between most of the variables, but the time variable 11D (question D on RMA model) and 20E (question E on Training model) were found to be significantly different between the two groups. The questions belonging to these two variables are:

- Question 11D: "Does the customer receive a reminder when the broken part has not been returned within 30 days?"
- Question 20E: "Is the 3rd party logistics in direct contact with the account manager?"

The boxplots in figure 9 on the time variable 11D and 20E show clear differences between the two groups. As both time variables are normally distributed, an independent T-test was conducted. The independent T-test indicated that participants from the Plural model (Group 1B2A, M = 81.50, SE = 39.74) needed significantly more time $t(19) = -2.60$, $p < 0.05$ to answer question 11D than participants from the classical model (Group 1A2B, M = 42.55, SE = 28.65) with a large effect size of r = 0.48. However, the independent T-test on variable 20E showed (significant Levene's test, so equal variances not assumed) that participants from the Plural model (Group 1A2B, M = 40.36, SE = 16.46) needed significantly less time $t(11.4) = -2.87$, $p < 0.05$ to answer question 20E than participants from the classical model (Group1B2A, M = 82.00, SE = 43.11) with a large effect size of r = 0.65.

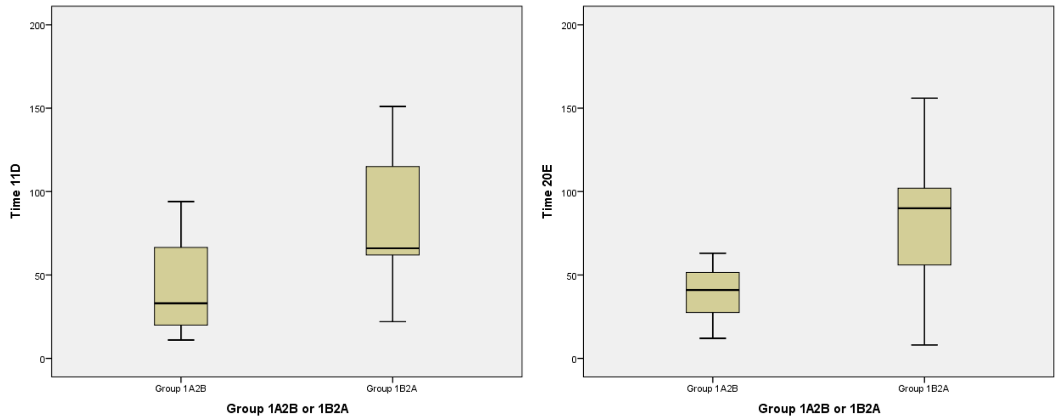


Figure 11: Boxplots mean time 11D and 20E for both groups

For variable 11D this difference can be explained by the way the Plural model is modeled. Because there are sub-processes designed in the Plural model, particular information is hidden from the non-unfolded model. This is the case with question 11D where it is necessary for the participant to unfold the right operation to get to the answer. This is not necessary for the classical model which leads to the difference in time in favor of the classical model.

Question 20E however needs a different explanation. The organizational units are modeled in the same way in both models with swim lanes indicating the responsibility from each department. The difference in time could be explained by the size of the model. As the models were displayed digitally in ARIS it could be that it was harder to follow the arcs in the classical model than in the Plural model. Moreover an AND-SPLIT is modeled in the classical model, although not connected to the account manager in any way, in contrast to the document flow in the Plural model which might be make it easier to interpret the relationships between departments.

Two different process models have now been compared to each other on two different processes. However, it might also be interesting to investigate the differences between the RMA process and the training process using the same modeling technique. This might explain some of the interesting differences that could be seen from both previous analyses. Although no particular differences could be discovered between the processes with the classical modeling technique, difference were discovered between the processes with the Plural technique. The following box plots displayed in figure 10 show that there is a difference between the mean total perceived and mean total time. Although the difference in time is not statistically significant, the difference in perceived is significantly different. The independent T-test indicated that participants from the Training process (M = 44.91, SE = 12.49) were significantly less satisfied in terms of PU, PEOU, ITU and UIS $t(18) = -3.05$, $p < 0.01$ than participants from the RMA process (M = 61.33, SE = 11.34) with a large effect size of r = 0.58. However, the training process took less time for the participants to answer the questions than the RMA process.

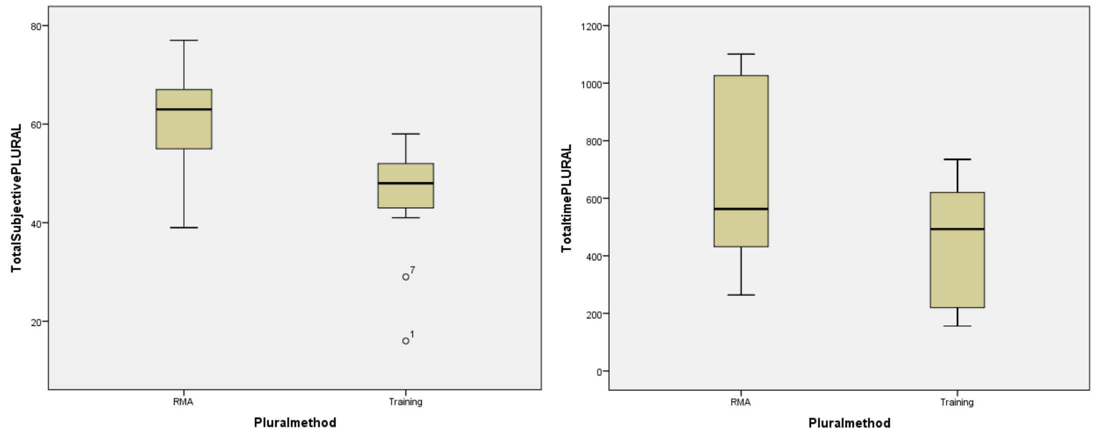


Figure 12: Boxplots Plural perceived and time on RMA and training model

Apparently the Plural method is more beneficial for the RMA process than the training process from an end-user perspective. Although SCORE, perceived difficulty and the amount of time spent has better scores for the training model, the participants ultimately choose the RMA process to be more preferable. This result seems to be similar to the results of the Plural model against classical model comparison on the RMA process.

5.7 Conclusion

Although the sample size is relatively small with 21 participants and two different processes modeled in two different ways making it difficult to make strong claims, some remarkable (although not all significant) results have been found.

Hypothesis	Accepted/rejected	Short explanation
H1: The amount of time participants spend on the understandability questions takes less time for the classical models than for the Plural models.	Results inconclusive	The classical RMA model does take less time (although not significantly), however, for the training model this is not the case. There might be a learning effect that influences the results.
H2: The classical models are more positively related to the SCORE of the understandability questions than the Plural models.	Results inconclusive	On both process models the SCORE is higher for the classical models, however not significantly. The hierarchical structure of the Plural models might be the cause of the difference.
H3: The classical models score higher on the perceived factors than the Plural models.	Results inconclusive	The classical training model does score higher on the perceived factors, although with the exception of PEOU. The classical RMA model however scores lower. It is difficult to give an explanation for this result. Again these differences were not statistically significant.

Table 8: Summary conclusions hypotheses

It was expected that the classical models would take less time which was only the case for the RMA model. The training model took on average more time in the classical way than it did in the Plural way. Furthermore a learning effect could be discovered in both models; however the learning effect was stronger for the Plural technique in the training model than the classical technique. Apparently this learning effect influences the amount of time spent on each question, which can be explained by the lack of SPLITS and JOINS in the training model.

The SCORE variables show, corresponding to the hypothesis, that the SCORE is indeed higher for the classical models than for the Plural models, although no significant differences were found. A possible explanation for this result could be the hierarchical structure of the Plural models. This might have led to a lower score for these process models.

The findings suggest that the scores on perceived difficulty are as expected; both classical models seem to be easier than their Plural counterparts, although the difference is relatively small. However, the scores on ITU, PU, PEOU and IUS do not correspond with these outcomes. For the RMA model the Plural technique was rewarded with higher scores in contrast to the training model where the classical technique was judged better.

The two processes are difficult to compare and as such differences may occur in the results. Therefore an attempt is made to look into the differences between the processes. Apparently, no differences could be found between the classical models, however the Plural models showed remarkable differences in both time as perceived. Especially perceived was remarkably lower for the training model than for the RMA model. This cannot be explained by the demographics of the participants. Most of the participants already know the processes to some extent. This might influence their judgment on how useful a modeling technique might be for that process. This could explain why the RMA model might be better modeled according to the participants with the Plural technique and the training model with the classical technique.

From an end-user perspective it could therefore be concluded that in a model with higher complexity (RMA) the Plural technique is preferred and in models with lower complexity (training), the classical technique is preferred. The tipping point is however hard to define and needs more research.

Fact: Managers tend to score higher on the questions than the employees, although not significantly.

6 Lessons learned

The Plural modeling technique is still in its infancy. It was developed in 2007 and since evolved in an extensive modeling technique in the field. However, it remains unclear what the main issues and benefits are when using the technique to model processes. For this research it was therefore registered which problems and advantages the technique has while designing the models using the technique. This could be done, because in contrast to what the modeling method essentially prescribes, the models were designed by the researcher instead of the employees themselves. As a result this section elaborates on how certain parts of the process can be addressed, which issues have been detected and what benefits the technique has.

6.1 Interviews

Before starting designing the model, of course one needs to gather information that is necessary for modeling the process. This information is more extensive than the information that is usually captured for classical modeling. Therefore, more time needs to be planned for the interviews with employees. In addition, an important aspect within this technique is the documents flow. Therefore, it is beneficial when the researcher not only asks what documents and systems are being used by the employee, but also sees what is incorporated or registered in these documents and systems. This can also be used as input for optimizing the process, not only from a process point of view, but also for data monitoring and data analysis later on.

The order of the interviews is also of importance. When starting with the manager who can give an overview of the complete process and the people who are involved, it gives a good start for planning the interviews in the right order. The interviews can then be planned in order of the process itself. So start the interview session with the employee where the process starts, working your way through to the employee where the process ends. Although in practice this is not always possible due to busy schedules of the workforce, it does give the researcher a heads up when interviewing the employee next in line. This involves particularly the document flow that is usually the trigger for the next in line to start with his job. Miscommunication and problems alike are usually detected during this phase. Also the perception of managers about how the process works has been noted as aberrant to what actually happens at the work floor. Although the Plural modeling technique asks for a more detailed description of the process, the way information is gathered is comparable to the classical technique.

6.2 Modeling of processes

When the interviews have taken place, the process models can be designed. When it comes to modeling processes it is always a consideration what the level of detail should be. There are no strict guidelines on the determination of the level of detail that is needed for a process model. This is dependent on what the purpose of the model is. For challenging IT projects it is very useful to have a very detailed process model, but for localizing main problem areas the detail can be limited to relatively global process flows. The level of detail should therefore be determined prior to the modeling phase.

For the purpose of this research first the classical model was designed. After the classical model was designed the researcher was trained in the Plural technique which could then be applied to the processes. Apparently this gave different insights into how the process works and is carried out by the employees. As a result the classical model could be extended with additional information from the Plural model. The (de)activation by the Hotline admin was overlooked in the classical model, but not in the Plural model due to the documents flow that showed the real purpose of this process. Moreover, additional problems could be detected as extra information was needed from the employees to model the processes in the Plural way. This is of course subjective to the researchers' perception, although due to the different view point that Plural requires it is not unlikely that this would be common to other modelers as well.

For the classical way of modeling guidelines have been proposed to make the models as easy and understandable as possible for the user. Although many proposed guidelines can be adopted for the Plural modeling technique, the guidelines can be complemented aimed at the Plural modeling technique. This implies the amount of symbols that are going to be used. Because of the extended information, besides activities, events, AND-, OR-, XOR-splits, documents and databases are also incorporated in the model. For the readability of the model it is therefore recommended to use a limited amount of symbols. In order to accomplish that, documents could for example be used for multiple purposes, like for an e-mail, but also for hardware that travels from one side to the other.

Other guidelines that could be added, which were discussed with the participants, are the following:

- Crossing lines should be reduced to a full minimum to enhance readability. This has been a problem for some experienced employees that use Visio for process modeling. They indicated that both models were a huge improvement in relation to this aspect. Especially, the swim lanes for the different departments made a beneficial improvement to the models.
- To improve consistency, the input of an activity should be modeled from the left hand side and the output on the right hand side as much as possible.
- Determine what operations take place by the actor. These are usually more than one operation, but the challenge is how/where to separate them. Some operations can be united while others have to be separated. There is not a clear guideline for doing this, but just common sense and thinking about the readability and ease of use of the model.
- When communication is going back and forth between two departments during one operation, this must be clear enough so it can be assumed the reader understands what is happening. This can be done by providing as much information as possible in the description of events and activities.

When the processes are modeled and need to be communicated with different employees in the company another limitation rises. It is difficult to hand out the plural model on paper due to the hierarchy. For practitioners this might be a limitation, as the underlying processes need to be printed separately. As a consequence the process models need to be shown digitally, preferably with the use of special software like ARIS business architect.

A limitation that was found when modeling the processes in the Plural way was the chronological order of the operations. The classical model consists of a flow that guides the practitioner through the model. In Plural however, it remains difficult to incorporate a chronological order in some processes. This was confirmed by some participants thinking that the vertical level of a process indicates its priority.

Although the guidelines of process modeling mentioned in CH3 were used in order to create high quality process models it remains difficult to apply them to processes in practice. It then depends on the granularity level, how large the model becomes and that is directly dependent of its purpose. Also an attempt is made to reduce the amount of splits in the models, but this is also subject to the process flow. They therefore remain guidelines and should be treated as such.

6.3 Opinions and remarks participants

After every experiment the participants were asked for their opinion and remarks on both models. Multiple participants indicated that the Plural model is quite difficult in the beginning, but becomes easier after some time is spend on the model. If more time was available to fully understand the Plural model it might have positively influenced the results. Furthermore, in the Plural model it was unclear for some participants, whether it is possible to continue in the model before a document is completely finished.

Besides these opinions, multiple proposals were suggested to improve or adjust the models for usage in a business environment. The following statements are a selection of the statements that have been recorded and are related to the models themselves, but also to the usage of the software package ARIS:

- "I would like more information about what is recorded in for example CRM to train new employees".
- "Freeze the department lanes, so when scrolling through the model they still remain visible."
- "Make the XOR/OR/AND-splits more visible with for example a brighter color. It now can be overlooked quite easily."
- "Implement vertical operations on the left hand side in Plural to have a quicker look at what kind of operations occur."
- "I would prefer a manual that comes with the model, so it would be less error sensitive".

6.4 Effect of modeling techniques on challenges faced by Company X

The process models were not only used for the comparison of the two modeling technique outputs. From a practical side it also functioned as an instrument for discovering problems the RMA process and installation and training process. It is therefore interesting to see how the different approaches lead to discovering problems within the processes. Although it is completely subjective, it could give some insights into the actual benefits of the process modeling techniques.

It is this aspect of looking for the problems in the processes, where the Plural modeling method seems to be preferable over the classical method. Due to the importance of the document flows and the actors in the process, some issues arise that would otherwise have been more difficult to find. A clear example of such an issue is the fact that the agreement form can be send back to Company X in different ways and to different departments. As in the classical method it is less interesting, the researcher is more dependent on the input from the employees during the interviews to get this information. This is in contrast to the Plural way where it is necessary to know where certain documents come from and where they are heading. This linkage between different operations has been found to be particular interesting when extra information is needed. It is only then that the employee is asked for additional information that might explain certain issues that would otherwise have been overlooked.

7 Conclusion & discussion

This study compared the output of two business process modeling techniques in order to investigate whether the new modeling technique, Plural, is a beneficial addition to the field of Business Process Management. This was done by modeling two different processes from the operations department at Company X, the RMA process and training/installation process. These were then compared via a non-empirical and empirical study. Five sub questions were defined in order to answer the main research question.

1. The main difference between classical business process modeling and Subject-oriented business process modeling is their approach. The Plural processes have actors that are responsible for their operations. In essence an operation is a small process model which has a start and end-event. These operations are connected via documents that flow from one department to the other. These documents are the trigger for the next department to take action and start their operation. This also indicates that when an actor is finished with his operation, his job is done, until he receives another document to start the same or a different operation again. This in contrast to the classical models, where the approach is to create a flow that can be followed from the start of the process to the end of the process. An event is followed by an activity and subsequently by an event again. This way the practitioner just follows the flow of the chart to eventually reach the end event which ends the process.

2. As the literature background has shown there are multiple options for comparing process models. For the purpose of this research a choice was made to conduct both a non-empirical and an empirical study. The non-empirical study was aimed at comparing the process models on their metrics which is an objective measure to indicate which process model is better to understand. The empirical study aimed at involving the employees at the company to judge the models on different factors via a survey. These factors were translated into the third sub question.

3. Moody (2003) defined a way to incorporate the perception of employees in order to judge the information system design into a survey. This was translated to the comparison assignment of this thesis in order to judge both models on these aspects. These aspects were the following:
    a. Perceived ease of use (PEOU)
    b. Perceived usefulness (PU)
    c. Intention to use (ITU)

    These aspects were complemented with four questions from Seddon & Yip (1992) measuring user information satisfaction (UIS) in terms of adequateness, efficiency, effectiveness and satisfaction. Another part aimed to elicit the understandability of the process models. This part consisted of six questions per process model which were formulated using three different perspectives (two questions per perspective) defined by Aalst (2000) and were formulated similarly to Mendling, Reijers, & Cardoso (2007):
    4) The process perspective
    5) The organizational perspective

6) The information perspective

4. A separate chapter has been dedicated to what can be learned from the way the processes are modeled by two different techniques which involve different approaches. The chapter shows that additional guidelines have to be formulated in order to create better understandable process models in the future. Moreover, the Plural modeling method was perceived as a good alternative for the way of designing process models. However, employees did mention that training would perhaps increase the understandability and intention to use the method in the future.

5. The non-empirical as well as the empirical study showed that the process models did not differ substantially from each other. They were judged more or less the same on their metrics as well as the perception of employees. This makes it fairly difficult to indicate whether one process model is preferable over the other. Moreover, the differences between the RMA process models did not completely match the differences between the training process models. However, on some aspects significantly differences were found between the models. On the RMA model the Plural process model was rated significantly higher for the ITU and satisfaction than the Classical model. The time variable 11D (question D on RMA model) and 20E (question E on Training model) were also found to be significantly different between the two groups. For the first variable the classical model was preferable in terms of time, on the second variable the Plural model was more preferable.

The contrasting results indicate that more research is needed to judge whether the Plural models are better in terms of understandability than the classical models. Whether the Plural method and thus Subject-oriented business process modeling is therefore a beneficial addition to the domain of business process management remains unanswered and needs further research.

7.1 Limitations

There might be certain pitfalls when performing this research by comparing process models derived from two different modeling techniques. At first all the models were designed by the same researcher. As the modeling process starts with the classical way of modeling, this does give the researcher already an idea of the process and so might influence the way the Plural method is performed. Because the researcher is not yet familiar with the Plural method when starting the classical technique a part of this issue is solved. However, this issue has to be treated with caution.

Furthermore, the research is limited because the Plural method has not been performed according to the defined rules. The idea is that employees themselves model their own processes, but because they do not have prior knowledge of modeling processes this would be very difficult. In addition, it is an advantage as well, because all the employees judged the models the same way, without being biased by already modeling a part of the process.

When modeling business process models a recurring issue remains the level of detail. Especially when a comparison has to be made, both models should have the same level of detail. The researchers have tried to control for this variable to model according to the guidelines of process modeling defined by Becker, Rosemann, & Uthmann (2000), Schuette & Rotthowe (1998) & Mendling, Reijers, & Van der Aalst (2010). Furthermore, the models were verified by domain experts and validated by employees from the company in order to try to minimize differences in the level of detail.

Another limitation in line with the level of detail is the level of modularity. The plural model uses modularity while the EPC model does not. This is a large difference that has to be taken into account and could have influenced the results of this study. However, the Plural models and classical models are at first instance almost equally in size (without sub processes) and both incorporate the same information. Therefore, the metrics were split up, so a complete view could be given.

Also, the documents and databases that were modeled for both processes and techniques were not incorporated in the metrics part. These elements might have an influence on the theoretical understandability; however this was controlled by asking for the perception of the participants. In addition, these elements are key issues in the Plural models and could therefore not be eliminated.

At last the total sample for the survey is rather limited. This is of course subject to the size of the company. It does however give a first impression on the evaluation of the processes from an end-user perspective. Although further research is needed to confirm the results generated by this research.

7.1.1 Internal validity

The following variables were controlled as part of this research (Moody D. L., 2002):

- Participant demographics: Due to random assignment of participants to the groups this was controlled.
- Complexity of experiment: The same models were used for both groups.
- Experimental setting: The experimental setup, with two laptops and the same level of detail was proposed to every subject, as well as the instructions that were consistent across the groups.

This experiment can therefore be judged as internally valid.

7.1.2 External validity

In order to maximize the external validity of this research certain strategies were used:

- The models that were used for this research were derived from a real world environment, which is therefore applicable for generalization.
- The models were verified by a modeling expert and validated by a process expert.
- The elements were not recoded by capital letters or such, to eliminate process knowledge. In order to keep generalizability, the participants were instructed that the process models as modeled for the experiment could differ from their experience. However, participants could therefore apply a different strategy for answering the understandability questions, which could have influenced the results.

The external validity is somewhat weaker than the internal validity. Although the models were derived from a real world environment and verified and validated by experts, the participants might have influenced the results due to their process knowledge. However an attempt was made to correct for this, but using participants outside of the organization, like students for instance, would have strengthen the research.

7.2 Future work

The results of this research and the limitations discussed in the previous section lead to several directions for further research. One expansion of the current research would be to extend the study with a larger sample size. The additional data could lead to a better understanding of the differences between the models and lead to stronger conclusions. Furthermore, only two different process models have been compared. Also the amount of processes and their models could be extended in future work, in order to further strengthen the differences between the Plural and the classical models.

Another addition would be to test the process models with participants who are not familiar with the processes. Due to the small sample size the difference in background of the participants could not be related to the end results. For future work the understandability of process models could be measured more accurately when participants are not part of the process.

At last more work is needed on process model metrics, especially on model complexity and understandability. At this point in time, only a very limited amount of metrics are available that has been proofed to be related to the understandability of classical process models. Furthermore, the difficulty remains to interpret the results correctly, for example, is a difference of 0.01 on the density metric a significant difference or should it be above or below a certain level.

7.3 Theoretical and practical contribution

This section elaborates on the practical and theoretical contribution of this thesis.

7.3.1 Theoretical contribution

The theoretical purpose of the thesis is to evaluate and test a new modeling technique that could be a beneficial technique in the field of business process management. The study provides insights into the vision of employees and experts in the field of process modeling on the two different models. The contribution to science is this comparison and the result of whether the new modeling technique is indeed a beneficial addition to this domain. The literature study has shown that this has not been investigated yet and because the new technique is relatively new, the results contribute to the field of business process management.

7.3.2 Practical contribution

This research is conducted at Company X at the Netherlands. The company has challenges with their operations in the field of the installation service and the reverse logistics. As the company would like to have solutions for these challenges this research has been conducted. The outcome was a separate document with a set of recommendations to Company X to improve or modify their processes. The research shows as well how the processes are related to industry benchmarks. With this information Company X has the opportunity to enhance their customer service level and as a consequence create a better market position.

8 Bibliography

Aalst, W. (1999). Formalization and verification of event-driven process chains. *Information and software technology*, 639-650.

Aalst, W. (2000). Workflow verification: Finding control-flow errors using Petri-net-based techniques. *W. Van der Aalst et al. (Eds.) Business process management, LNCS 1806* (pp. 161-183). Berlin Heidelberg: Springer-Verlag.

Aalst, W. V., Hofstede, A. T., & Weske, M. (2003). Business process management: a Survey. *In: W.M.P. van der Aalst et al. (Eds.): BPM 2003, LNCS 2678*, 1-12.

Aitenbichler, E., & Borgert, S. (2010). Application of subject-oriented modeling in automatic service composition. *H. Buchwald et al. (Eds.): S-BPM ONE, CCIS 85* (pp. 71-82). Berlin Heidelberg: Springer-Verlag.

Aitenbichler, E., Borgert, S., & Mühlhäuser, M. (2011). Distributed execution of S-BPM business processes. *A. Fleischmann et al. (Eds.): S-BPM ONE 2010, CCIS 138* (pp. 19-35). Berlin Heidelberg: Springer-Verlag.

Amini, M., & Retzalff-Roberts, D. (1995). Reverse logistics process reengineering: Improving customer service quality. *Issues in supply chain management*, 5(1): 31-41.

Bandara, W., Gable, G., & Rosemann, M. (2005). Factors and measures of business process modelling: modeling building through a multiple case study. *European journal of information systems*, 14, 347-360.

Bandara, W., Indulska, M., Chong, S., & Sadiq, S. (2007). Major issues in business process management: An expert perspective. *In Proceedings ECIS 2007 - The 15th European conference on information systems*, (pp. 1240-1251). St Gallen, Switzerland.

Becker, J., Kugeler, M., & Rosemann, M. (2003). *Process management.* Berlin Heidelberg: Springer-Verlag.

Becker, J., Rosemann, M., & Uthmann, C. (2000). Guidelines of business process modeling. *In: W. van der Aalst et al. (Eds.): Business Process Management, LNCS 1806, pp 30-49, 2000 Springer-Verlag Berlin Heidelberg 2000*.

Bloemhof-Ruwaard, J., Fleischmann, M., & Nunen, J. (1999). Reviewing distribution issues in reverse logistics. In M. Grazia Speranza, & P. Stähly, *Lecture notes in economics and mathematical systems* (pp. 24-44). Berlin-Heidelberg: Springer-Verlag.

Bridgeland, D., & Zahavi, R. (2009). *Business modeling: A practical guide to realizing business value.* Elsevier Inc.

Brito, M., & Dekker, R. (2003). A framework for reverse logistics. *ERIM report series research in management*.

Brito, M., Dekker, R., & Flapper, S. (2005). Reverse logistics: A review of case studies. *B. Fleischmann et al. (eds.) Distribution logistics.* Berlin Heidelberg: Springer-Verlag.

Broadbent, M., Weill, P., & St. Clair, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly*, Vol. 23, No. 2, 159-182.

Claes, J., Vanderfeesten, I., Reijers, H., Pinggera, J., Weidlich, M., Zugal, S., et al. (2012). Tying process model quality to the modeling process: The impact of structuring, movement, and speed. *A. Barros, A. Gal, and E. Kindler (Eds.): BPM 2012, LNCS 7481* (pp. 33-48). Berlin Heidelberg: Springer-Verlag.

Curtis, B., Kellner, M., & Over, J. (1992). Process modeling. *Communications of the ACM*, Vol. 35, No. 9.

Davenport, T. (1993). *Process innovation: Reengineering work through information technology.* Boston: Mass.: Harvard Business School Press.

Davies, I., Green, P., Rosemann, M., Indulska, M., & Gallo, S. (2006). How do practitioners use conceptual modeling in practice? *Data & knowledge engineering 58*, 358-380.

Dixon, J., & Jones, T. (2011). *Hype cycle for business process management.* Gartner.

Doran, J., & Gilbert, N. (1994). Simulating societies: An introduction. *In: Simulating, Societies: The computer simulation of social phenomena N. Gilbert and J. Doran (Eds.).* London: UCL Press.

Dumas, M., Aalst, W., & Hofstede, A. (2005). *Process-aware information systems: Bridging people and software through process technology.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Elzinga, J., Horak, T., Lee, C.-Y., & Bruner, C. (1995). Business process management: Survey and Methodology. *IEEE Transactions on engineering management*, Vol. 42, No. 2.

Fleischmann, A. (2010). What is S-BPM? *H. Buchwald et al. (Eds.): S-BPM ONE, CCIS 85* (pp. 85-106). Berlin Heidelberg: Springer-Verlag.

Fleischmann, A., Schmidt, W., Stary, C., Obermeier, S., & Börger, E. (2012). *Subject-Oriented business process management.* München: Springer.

Fleischmann, M., Bloemhof-Ruwaard, J., Dekker, R., Van der Laan, E., Van Nunen, J., & Van Wassenhove, L. (1997). Quantitative models for reverse logistics: A review. *European journal of operational research 103*, 1-17.

Garcia, H. (2011). *Evaluation of Data-centric process modeling approaches.* Eindhoven: Master thesis.

Ghani, A., Wei, K., Muketha, G., & Wen, W. (2008). Complexity metrics for measuring the understandability and maintainability of business process models using Goal-Question-Metric (GQM). *International journal of computer science and network security*, Vol. 8, No. 5.

Giaglis, G. (2001). A taxonomy of business process modeling and information systems modeling techniques. *The international journal of flexible manufacturing systems*, 13, 209-228.

Greenlaw, C., & Brown-Welty, S. (2009). A comparison of web-based and paper-based survey methods: Testing assumptions of survey mode and response cost. *Evaluation review*, Vol. 33, No. 5, 464-480.

Hammer, M., & Champy, J. (1988). *Reengineering the corporation.* Harper Business.

Hayslett, M., & Wildemuth, B. (2004). Pixels or pencils? The relative effectiveness of Web-based versus paper surveys. *Library & Information science research*, 26, 73-93.

Hedberg, S. (1996). AI tools for business process modeling. *IEEE Expert*, 13-15.

HU, P., & Chau, P. (1999). Examining the technology acceptance model using physician acceptance of telemedicine technology. *Journal of management information systems*, 91-113.

Huckvale, T., & Ould, M. (1995). Process modeling- Who, what and how: Role activity diagramming. *In: Business process change: Concepts, methods and technologies, V. Grover and W.J. Kettinger (Eds.)* (pp. 330-349). Harrisburg, PA: Idea group publishing.

Ibrahim, M. J. (2005). The effect of globalisation on the development of underdeveloped economies.

Indulska, M., Green, P., Recker, J., & Rosemann, M. (2009). Business process modeling: Perceived benefits. *In: 28th International conference on conceptual modeling, 9-12 November 2009.* Gramado, Brazil.

Indulska, M., Recker, J., Rosemann, M., & Green, P. (2009). Business process modeling: Current issues and future challenges. *In: P. van Eck, J. Gordijn, and R. Wieringa (Eds.): CAiSE 2009, LNCS 5565*, 501-514.

Jones, J. (1986). Structured programming logic: A flowcharting approach. *Prentice-Hall, Englewood cliffs, NJ*.

Ko, R., Lee, S., & Lee, E. (2009). Business process management standards: A survey. *Business process management journal*, Vol. 15, No. 5, pp. 744-791.

Koster, R., Brito, M., & Vendel, M. (2002). Return handling: An exploratory study with nine retailer warehouses. *International journal of retail and distribution management*, Vol. 30, pp. 407-421.

Krumwiede, D., & Sheu, C. (2002). A model for reverse logistics entry by third-party providers. *The international journal of management science*, 325-333.

Kühne, S., Kern, H., Gruhn, V., & Laue, R. (2010). Business process modeling with continuous validation. *Journal of software maintenance and evolution: Research and practice*, 22: 547-566.

LaLonde, B., & Zinszer, P. (1977). *Customer service: Meaning and measurement.* National council of physical distribution management.

Lambert, D., & Stock, J. (2001). *Strategic logistics management.*

Lee, R., & Dale, B. (1998). Business process management: A review and evaluation. *Business process management journal*, Vol. 4, No. 3.

Lindland, O., Sindre, G., & Solvberg, A. (1994). Understanding quality in conceptual modeling. *IEEE, software*, Vol. 11, No. 2, 42-49.

Lu, R., & Sadiq, S. (2007). A survey of comparative business process modeling approaches. *W. Abramowicz (Ed.): BIS 2007, LNCS 4439* (pp. 82-94). Berlin Heidelberg: Springer-Verlag.

Lusk, S., Paley, S., & Spanyi, A. (2005). The evolution of business process management as a professional discipline. *Bptrends*.

Maes, A., Poels, G., Gailly, F., & Paemeleire, R. (2005). *Measuring user beliefs and attitudes towards conceptual models: A factor and structural equation model.* Gent: Faculty of Economics and Business administration Ghent University.

Makni, L., Khlif, W., Haddar, N., & Ben-Abdullah, H. (2010). A tool for evaluating the quality of business process models. *Informatik 2010- business process and service science - proceeding of ISSS and BPSC.*

Mendling, J. (2006). *Testing density as a complexity metric for EPCs.* Retrieved from http://mendling.com/publications/TR06-density.pdf: Vienna University of Economics and Business Administration.

Mendling, J. (2007). *Detection and prediction of errors in EPC business process models.* Wien: Institute of information systems and new media, Vienna University of Economics and Business administration.

Mendling, J. (2008). *Metrics for process models: Empirical foundations of verification, error prediction and guidelines for correctness.* Berlin: Springer-Verlag.

Mendling, J., & Aalst, W. (2007). Formalization and verification of EPCs with OR-joins based on state and context. *In: J. Krogstie, A.L. Opdahl, and G. Sindre (Eds.): CAiSE 2007, LNCS 4495* (pp. 439-453). Berlin Heidelberg: Springer-Verlag.

Mendling, J., Reijers, H., & Cardoso, J. (2007). What makes process models understandable? *G. Alonso, P. Daman, and M. Rosemann (Eds.) BPM2007, LNCS 4714* (pp. 48-63). Berlin Heidelberg: Springer-Verlag.

Mendling, J., Reijers, H., & Van der Aalst, W. (2010). Seven process modeling guidelines (7PMG). *Information and software technology 52*, 127-136.

Moody, D. (2003). The method evaluation model: A theoretical model for validating information systems design methods. *ECIS 2003 Proceedings*, (p. 79).

Moody, D. (2005). Theoretical and practical issues in evaluating the quality of conceptual models: current state and future directions. *Data & knowledge engineering*, 55, 243-276.

Moody, D. L. (2002). Complexity effects on end user understanding of data models: An experimental comparison of large data model representation methods. *ECIS*, (pp. 482-496). Gdansk, Poland.

Muehlen, M. (2004). *Workflow-based process controlling. Foundation, Design and implementation of workflow-driven process information systems.* Berlin: Advances in Information Systems and Management Science, Vol. 6. Logos.

Nakamura, S., Tan, T., Hirayama, T., Kawai, H., Komiyama, S., Hosaka, S., et al. (2011). CGAA/EES at NEC Corporation, powered by S-BPM: The subject-oriented BPM development technique using top-down approach. *W. Schmidt (Ed.):S-BPM ONE 2011, CCIS 213* (pp. 215-231). Berlin Heidelberg: Springer-Verlag.

Nüttgens, M., & Rump, F. (2002). Syntax und semantic ereignisgesteuerter prozessketten (EPK). *In. J. Desel and M. Weske, editor, Proceedings of promise 2002* (pp. 64-77). Potsdam: Vol. 21 of Lecture Notes in Informatics.

Olbrich, T. (2011). Why we need to re-think current research issues. *A. Fleischmann et al. (Eds.): S-BPM ONE 2010, CCIS 138* (pp. 209-215). Berling Heidelberg: Springer-Verlag.

Peterson, J. (1981). Petri net theory and the modeling of systems. *Prentice-Hall, Englewood Cliffs, NJ* .

Pokharel, S., & Mutha, A. (2009). Perspectives in reverse logistics: A Review. *Resources, conservation and recycling*, 53(4), 175-182.

Pritchard, J.-P., & Armistead, C. (1999). Business process management - lessons from European business. *Business process management journal*, Vol. 5, No. 1, 10-32.

Recker, J., & Rosemann, M. (2010). A measurement instrument for process modeling research: Development, test and procedural model. *Scandinavian journal of information systems*, 22(2), pp. 3-30.

Recker, J., Indulska, M., Rosemann, M., & Green, P. (2009). Business process modeling: A comparative analysis. *Journal of the association for information systems*, Vol. 10, No. 4, 333-363.

Reijers, H., & Mendling, J. (2008). Modularity in process models: Review and effects. *In Business process management - BPM 2008*, ser. Lecture Notes in Computer Science, M. Dumas, M. Reichert, and M.-C. Shan, Eds. Milan, Italy: Springer 2008, vol. 5240, pp. 20-35.

Reijers, H., & Mendling, J. (2011). A study into the factors that influence the understandability of business process models. *IEEE transactions on systems, man, and cybernetics-Part A: Sytems and humans*, Vol. 41, No. 3.

Reijers, H., Mendling, J., & Recker, J. (2010). Business process quality management. *In Handbook on business process management 1* (pp. 167-185). Berlin Heidelberg: Springer.

Retzlaff-Roberts, D., & Frolick, M. (1997). Reducing cycle time in reverse logistics. *Cycle time research*, (3:1), 69-78.

Rogers, D., & Tibben-Lembke, R. (2001). An examination of reverse logistics practices. *Journal of business logistics*, Vol. 22, No. 2.

Rogers, D., Lambert, D., Croxton, K., & Garcia-Dastugue, S. (2002). The returns management process. *The international journal of logistics management*, Vol. 13, No. 2.

Rosemann, M., Recker, J., Indulska, M., & Green, P. (2006). A study of the evolution of the representational capabilities of process modeling grammars. *E. Dubois and K. Pohl (Eds.): CAiSE 2006, LNCS 4001* (pp. 447-461). Berlin Heidelberg: Springer-Verlag.

Rossi, M., & Brinkkemper, S. (1996). Complexity metrics for systems development methods and techniques. *Information systems*, Vol. 21, No. 2, 209-227.

Sarshar, K., & Loos, P. (2005). Comparing the control-flow of EPC and Petri Net from the end-user perspective. *W.M.P. Van Der Aalst et al. (Eds.): BPM 2005, LNCS 3649* (pp. 434-439). Berlin Heidelberg: Springer-Verlag.

Schuette, R., & Rotthowe, T. (1998). The Guidelines of modeling - An approach to enhance the quality in information models. *In: Ling, T. W., Ram, S., Lee, M. L. (eds.): Conceptual Modeling - ER '98. 17th International ER-Conference, Singapore, November 16-19, 1998. Springer-Verlag, Berlin et al. (1998)*, 240 - 254.

Schwegmann, A., & Laske, M. (2003). As-is modeling and process analysis. In J. Becker, M. Kugeler, & M. Rosemann, *Process management: A guide for the design of business processes* (pp. 107-133). Berlin: Springer-Verlag.

Seddon, P., & Yip, S.-K. (1992). An Empirical evaluation of user information satisfaction (UIS) measures for use with general ledger accounting software. *Journal of information systems*, 6(1) 75-92.

Sellner, A., & Zinser, E. (2011). Establishing conceptual and functional links between S-BPM and business rules. *A. Fleischmann et al. (Eds.): S-BPM ONE 2012, CCIS 138* (pp. 121-133). Berlin Heidelberg: Springer-Verlag.

Siau, K., & Rossi, M. (1998). Evaluation of information modeling methods - A Review. *IEEE Proc. 31st Annual Hawaii International Conference on system sciences*, (pp. 314-322). Kohala Coast.

Singer, R., & Zinser, E. (2010). Business process management - S-BPM a new paradigm for competitive advantage? *H.Buchwald et al. (Eds.): S-BPM ONE, CCIS 85* (pp. 48-70). Berlin Heidelberg: Springer-Verlag.

Trkman, P. (2010). The critical success factors of business process management. *International journal of information management 30*, 125-134.

Turetken, O., & Demirors, O. (2007). An approach for decentralized process modeling. *Q.Wang, D. Pfahl and D.M. Raffo (Eds.): ICSP 2007, LNCS 4470* (pp. 195-207). Berling Heidelberg: Springer-Verlag.

Turetken, O., & Demirors, O. (2008). Process modeling by process owners: A decentralized approach. *Software process improvement and practice; 13*, 75-87.

Turetken, O., & Demirors, O. (2011). Plural: A decentralized business process modeling method. *Information & Management*, 235-247.

Turetken, O., & Demirors, O. (2013). Business process modeling pluralized. *Subject-oriented business process management (S-BPM) ONE 2013, CCIS 360*, pp.34-51, Springer-Verlag Berlin Heidelberg.

Vanderfeesten, I., Reijers, H., Mendling, J., Aalst, W., & Jorge, C. (2008). On a quest for good process models: The Cross-Connectivity metric. *Z. Bellahsene and M. Léonard (Eds.): CAiSE 2008, LNCS 5074* (pp. 480-494). Berlin Heidelberg: Springer-Verlag.

Vergidis, K., Tiwari, A., & Majeed, B. (2008). Business process analysis and optimization: Beyond reengineering. *IEEE transactions on systems, man and cybernetics - Part C: Applications and reviews*, Vol. 38, No. 1.

Weske, M., Aalst, W., & Verbeek, H. (2004). Advances in business process management. *Data and knowledge engineering*, 1-8.

White, S. A. (2004). Introduction to BPMN. *IBM Cooperation*, 2008-029.

Yu, E., Mylopoulos, J., & Lesperance, Y. (1996). AI models for business process reengineering. *IEEE Expert*, 16-23.

Zairi, M. (1997). Business process management: a boundaryless approach to modern competitiveness. *Business process management journal Vol. 3 No. 1*, 64-80.

Appendix A: List of interviewees

1. Manager supply chain management
2. Project manager #1
3. Project manager #2
4. Installation engineer
5. Leader installation
6. Manager technical support
7. Senior technical support specialist
8. Administrative service coordinator
9. Account manager #1
10. Account manager #2
11. Logistics engineer at warehouse
12. Service Centre

Appendix B: E-mail to interviewees

Dear sir/madam,

Due to the final year of my study at the Technical University of Eindhoven I am now performing my graduation project at Company X in the Netherlands. I am studying Operational management & Logistics with a special interest for information systems and thus my research project will be related to this domain.

The research I will be carrying out at the operations department involves the return logistics process, also known as the RMA process, and the service installation process. As you might know there are some challenges with these processes and therefore I will model the processes that are involved. The purpose of the research will be to provide a set of recommendations to improve the RMA process, so there will be less operational difficulties, and a set of recommendations on how to arrange the service installation process to provide a better service to the customer.

In order to get to know and model the processes that are involved I would like to have a conversation of one hour that will provide me with the information I need for completing the project. So I would like to set up a meeting with you before 10^{th} May to discuss your part of the process. I will pass by Monday 6^{th} May to schedule a date.

Kind regards,

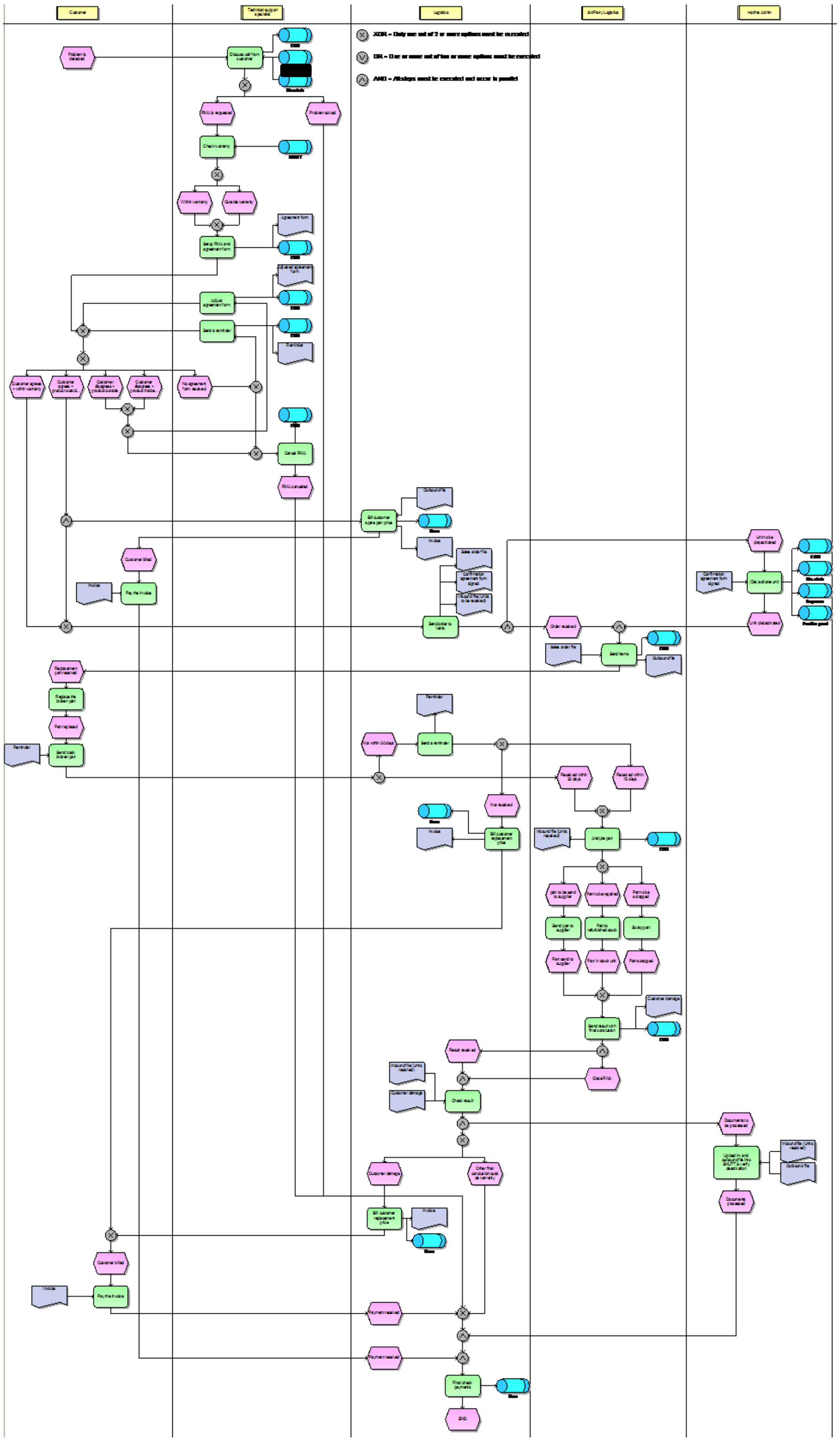
Aldwin Schroot

Appendix C: Questions for interview

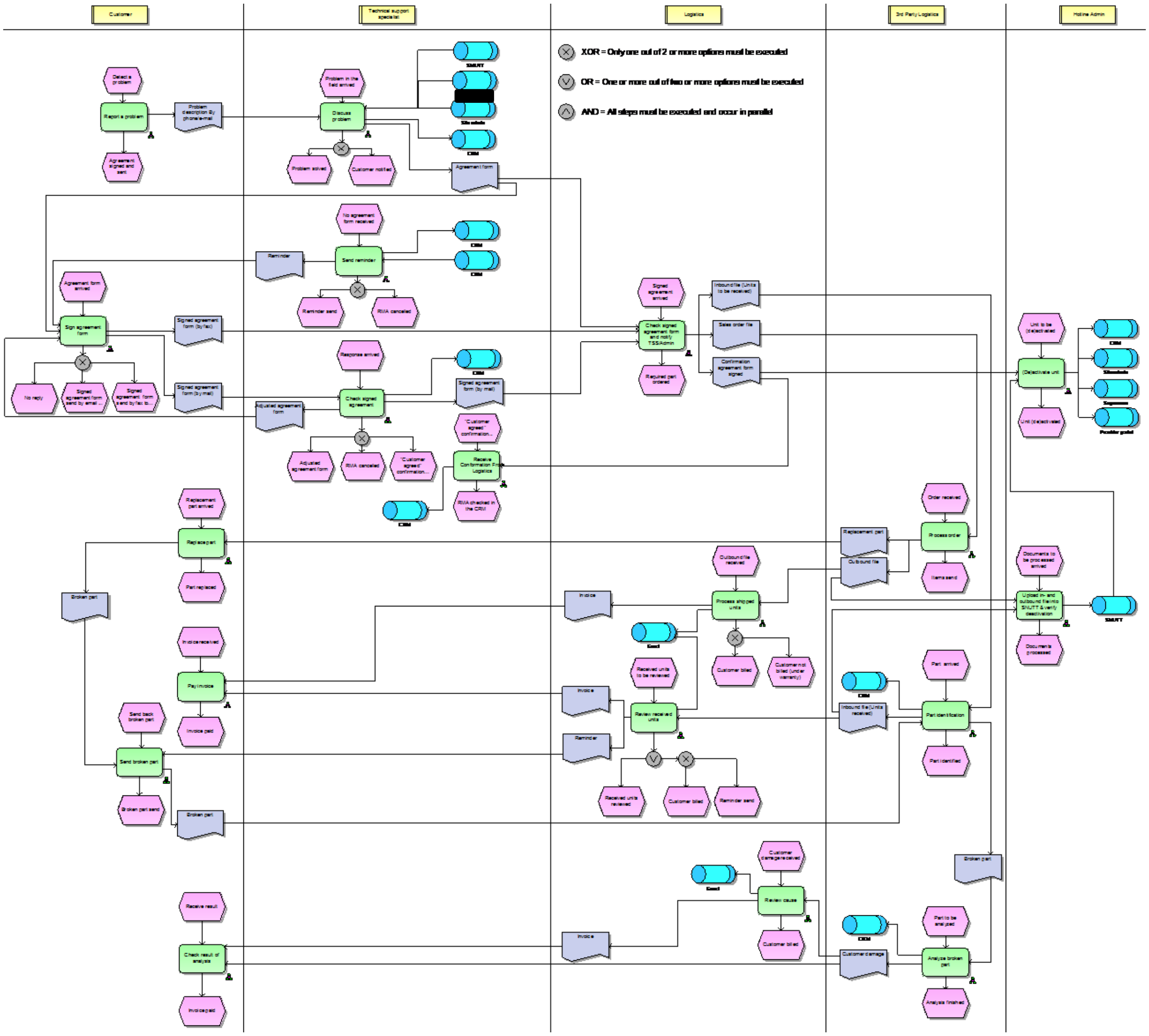
Name & Function interviewee:
Date:
What is the reason for this project and what do I expect from them…

1. How does the process start?
2. What event triggers the process to start?
3. Is there more than one way the process could start?
4. How do you know when the process is complete? (What are the determining factors?)
5. Are there different end states for the process? For example, one that signifies successful completion and others, indicating failed or aborted attempts.
6. How does the process get from point A to point B?
7. Where else might the process go and why?
8. How do you know when one part is done?
9. Are all changes documented? How many changes are done each month?
10. What are the normal end states and what are the exceptions?
11. Are there rules that govern the process, states, and completion status?
12. What parts of the process do you seek to eliminate, and why?
13. Where do you spend most of your time, and why?
14. Where in the process do you repeat work? How often, and why?
15. How does management assess the process and how it is performing?
16. Is there data available on for example registration dates?
17. Are there any things that are important to know?

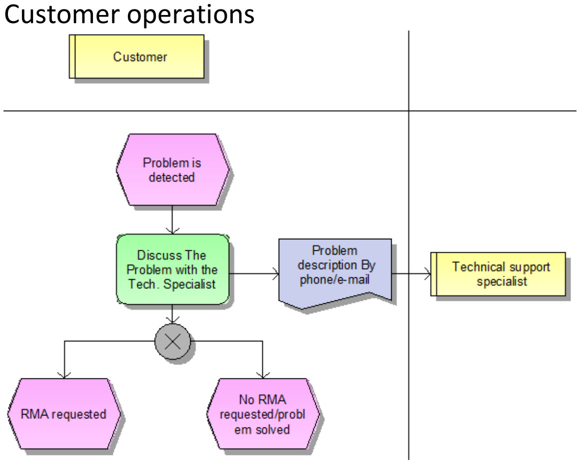
Appendix D: RMA Classical process model

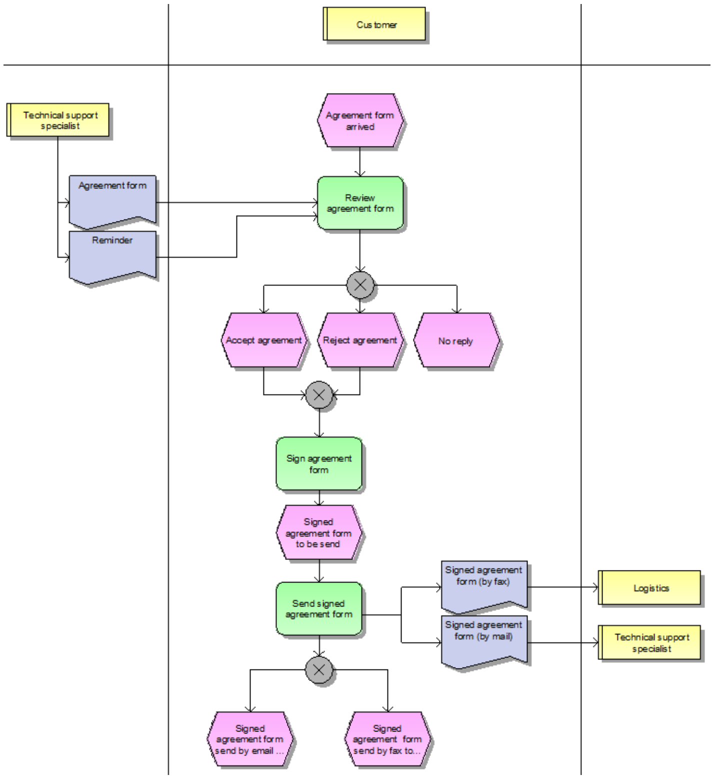


Appendix E: RMA Plural process model

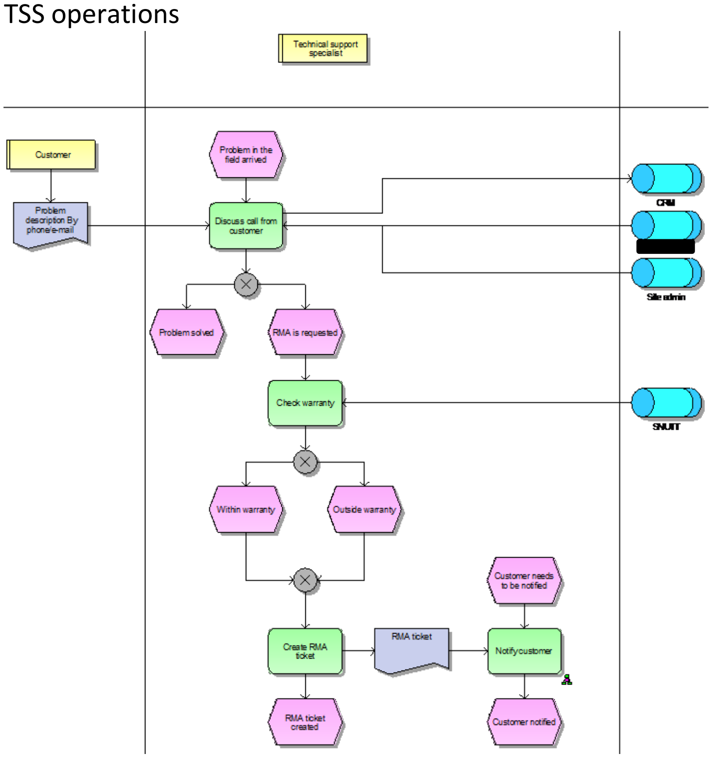


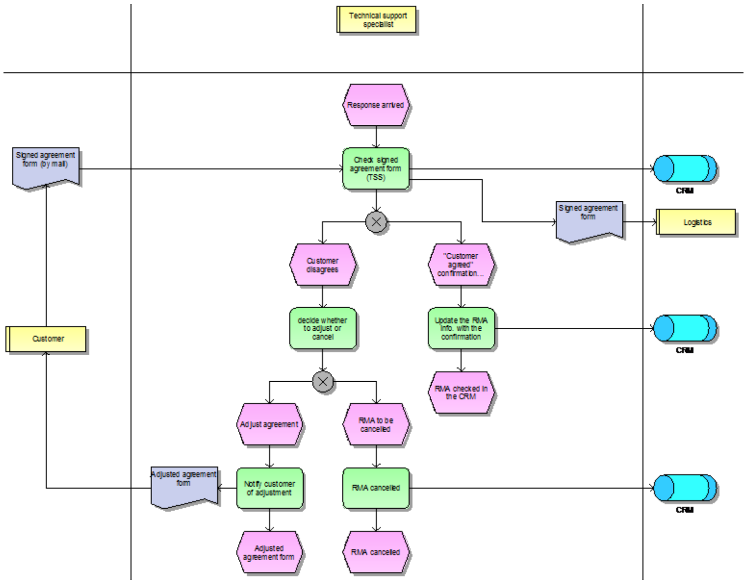
Customer operations



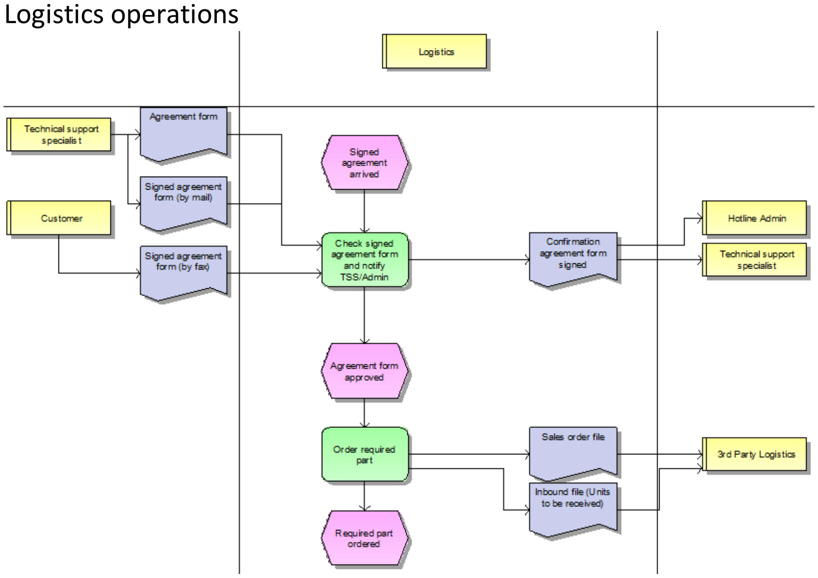


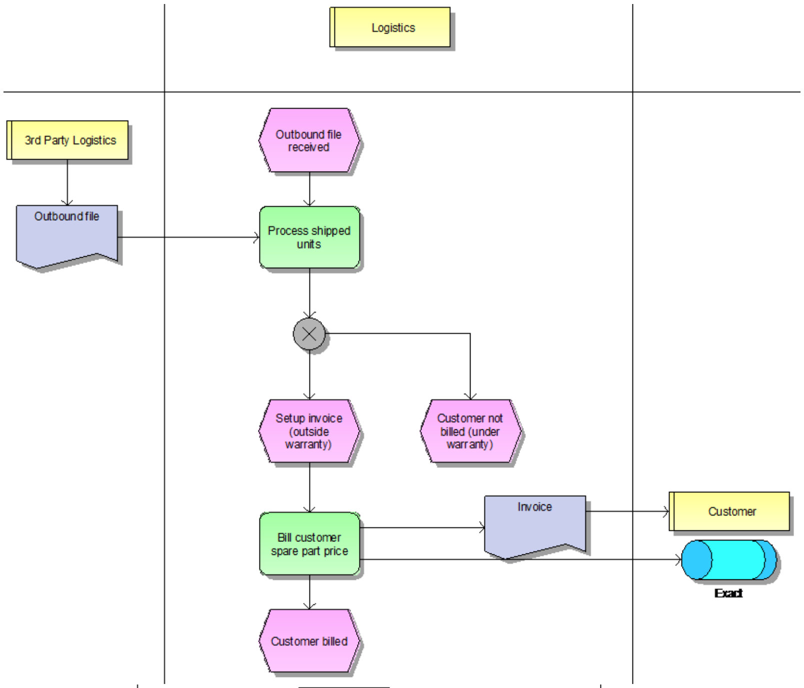
TSS operations



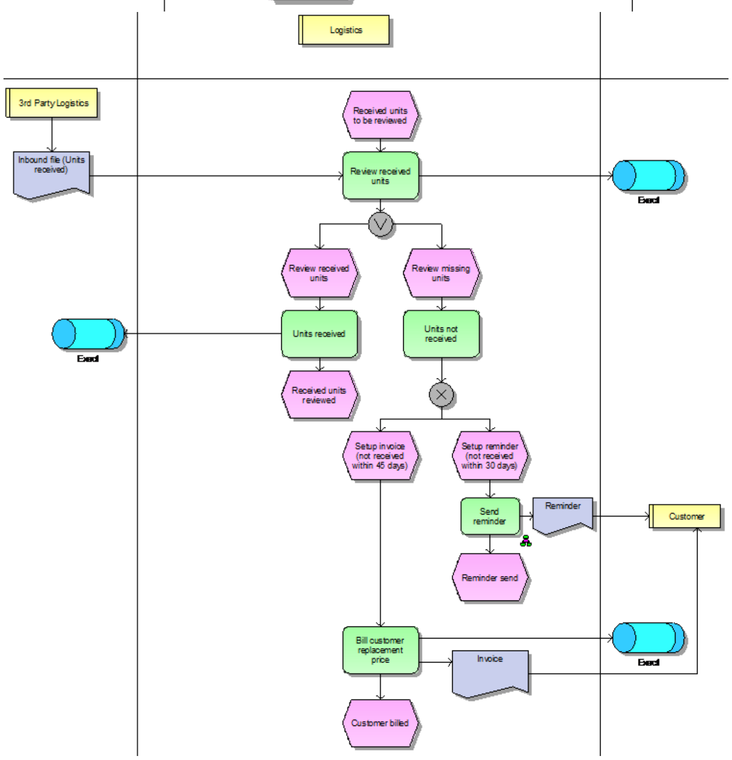


Logistics operations

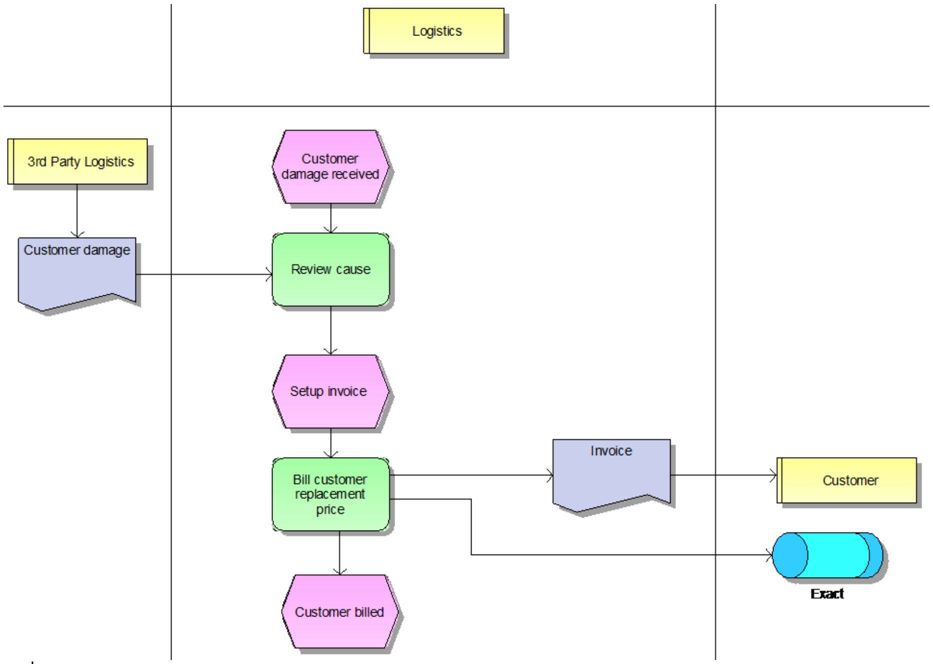




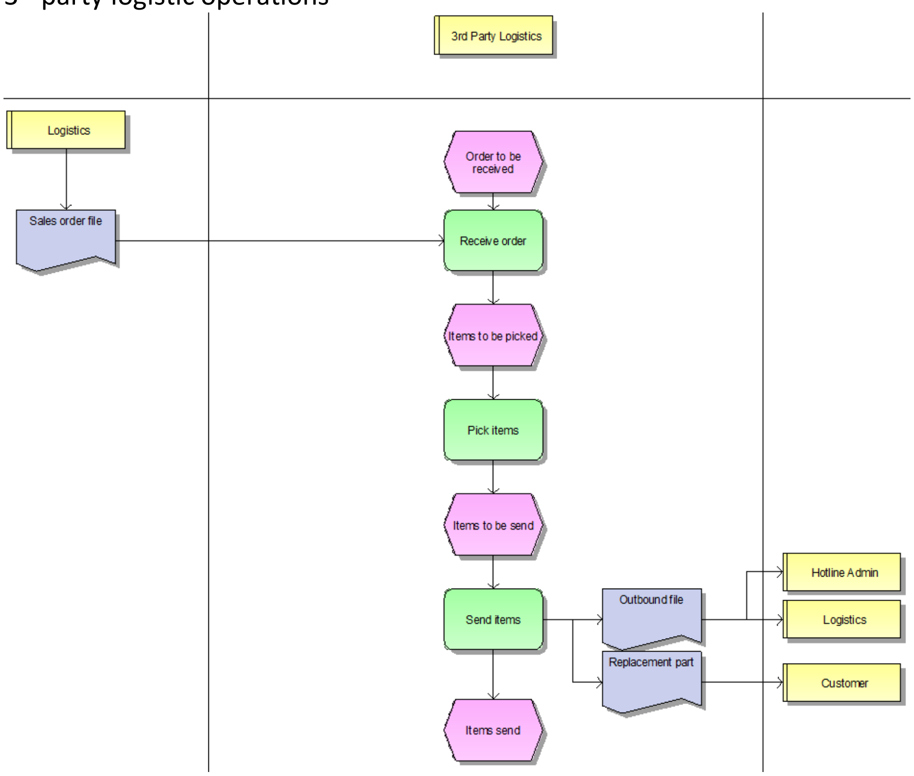
Logistics
3rd Party Logistics
Outbound file
Outbound file received
Process shipped units
Setup invoice (outside warranty)
Customer not billed (under warranty)
Bill customer spare part price
Invoice
Customer
Exact
Customer billed

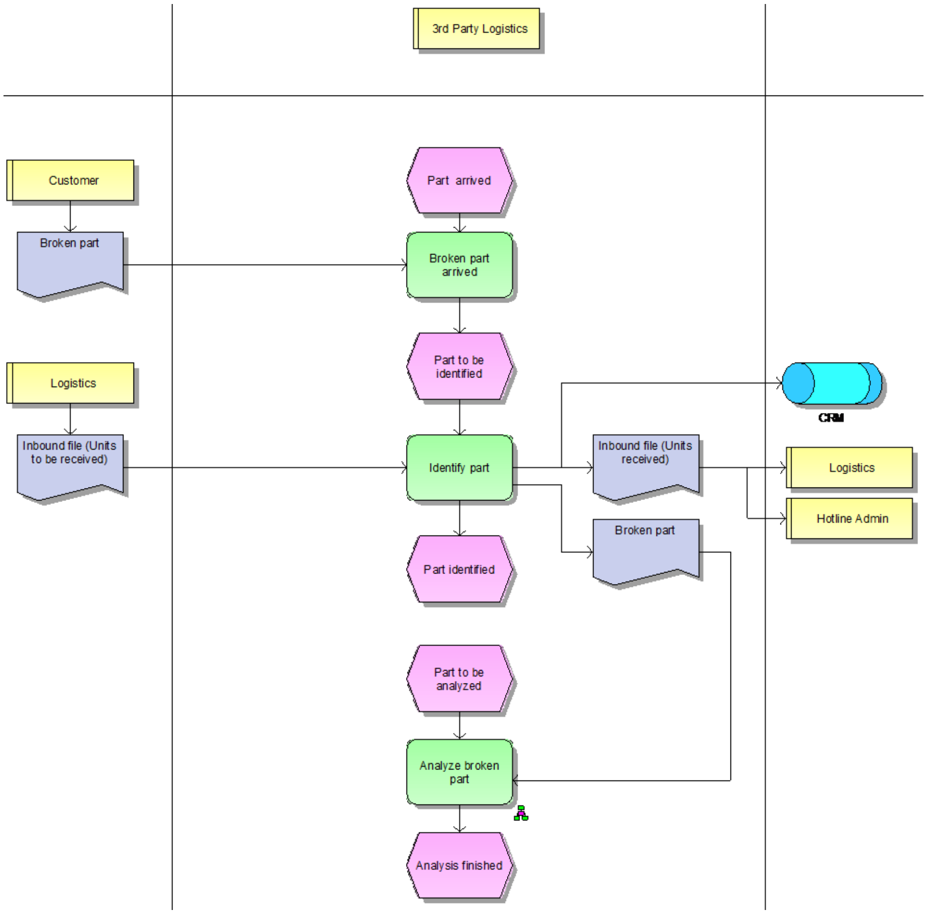


Logistics
3rd Party Logistics
Inbound file (Units received)
Received units to be reviewed
Review received units
Review received units
Review missing units
Units received
Units not received
Received units reviewed
Setup invoice (not received within 45 days)
Setup reminder (not received within 30 days)
Send reminder
Reminder
Customer
Reminder send
Bill customer replacement price
Invoice
Customer billed

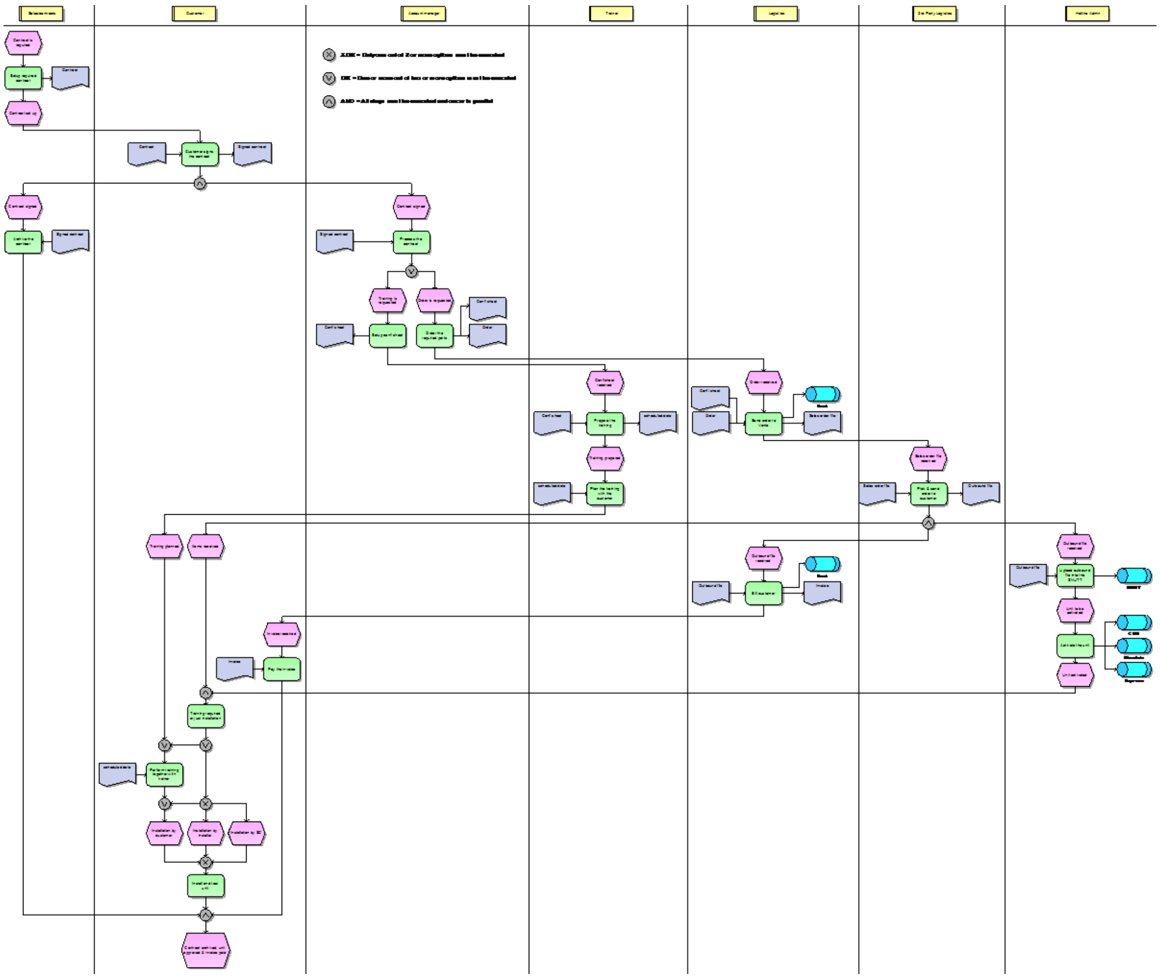


3[rd] party logistic operations

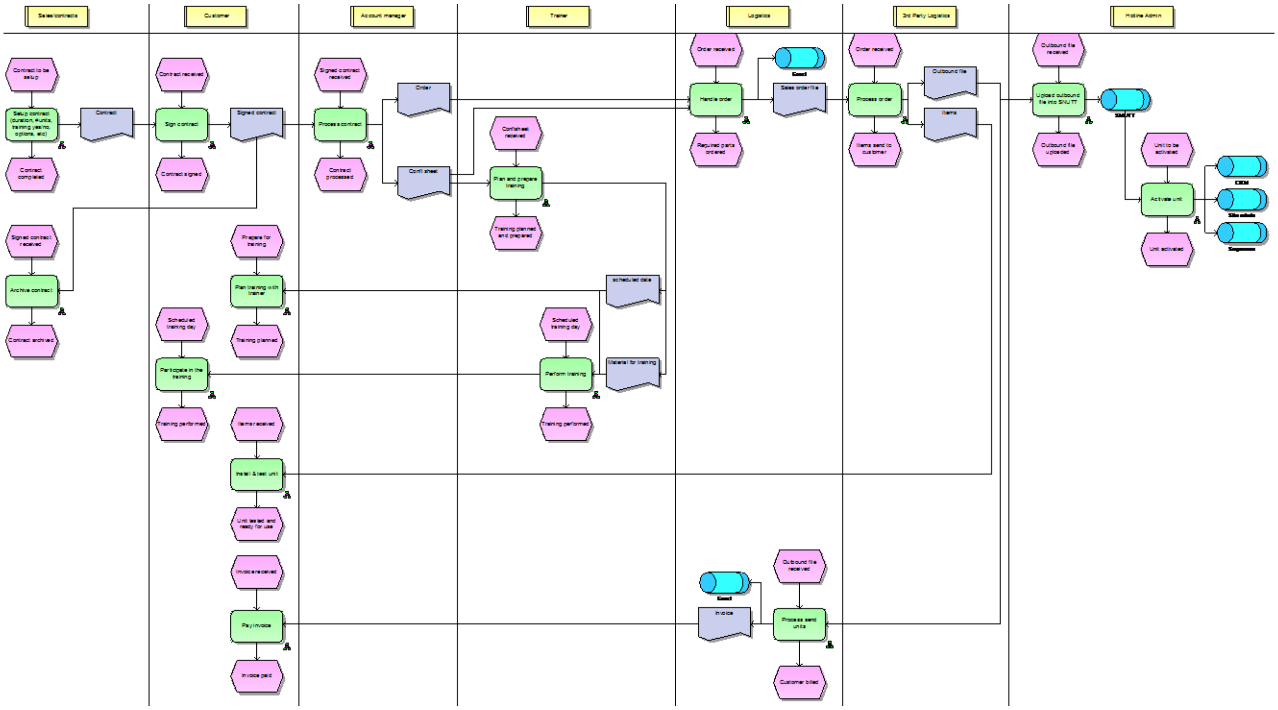



3rd Party Logistics
Customer
Broken part
Part arrived
Broken part arrived
Part to be identified
Logistics
Inbound file (Units to be received)
Identify part
CRM
Inbound file (Units received)
Logistics
Hotline Admin
Broken part
Part identified
Part to be analyzed
Analyze broken part
Analysis finished

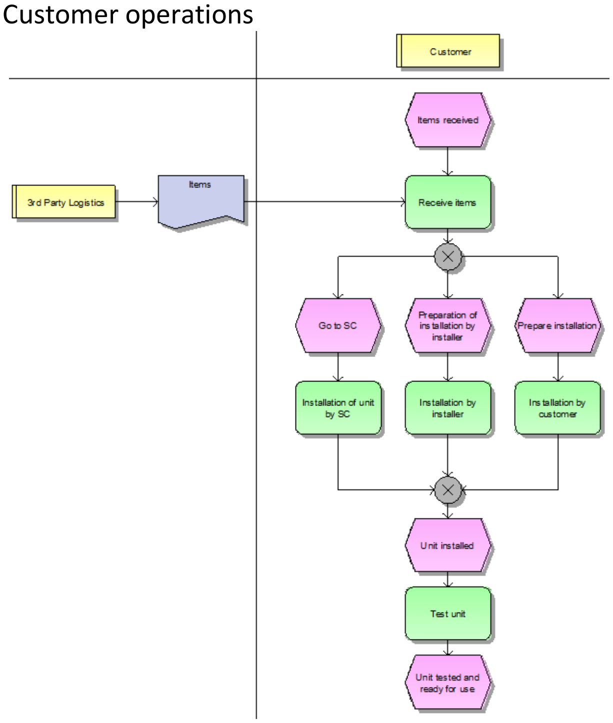
Appendix F: Training/installation Classical process model



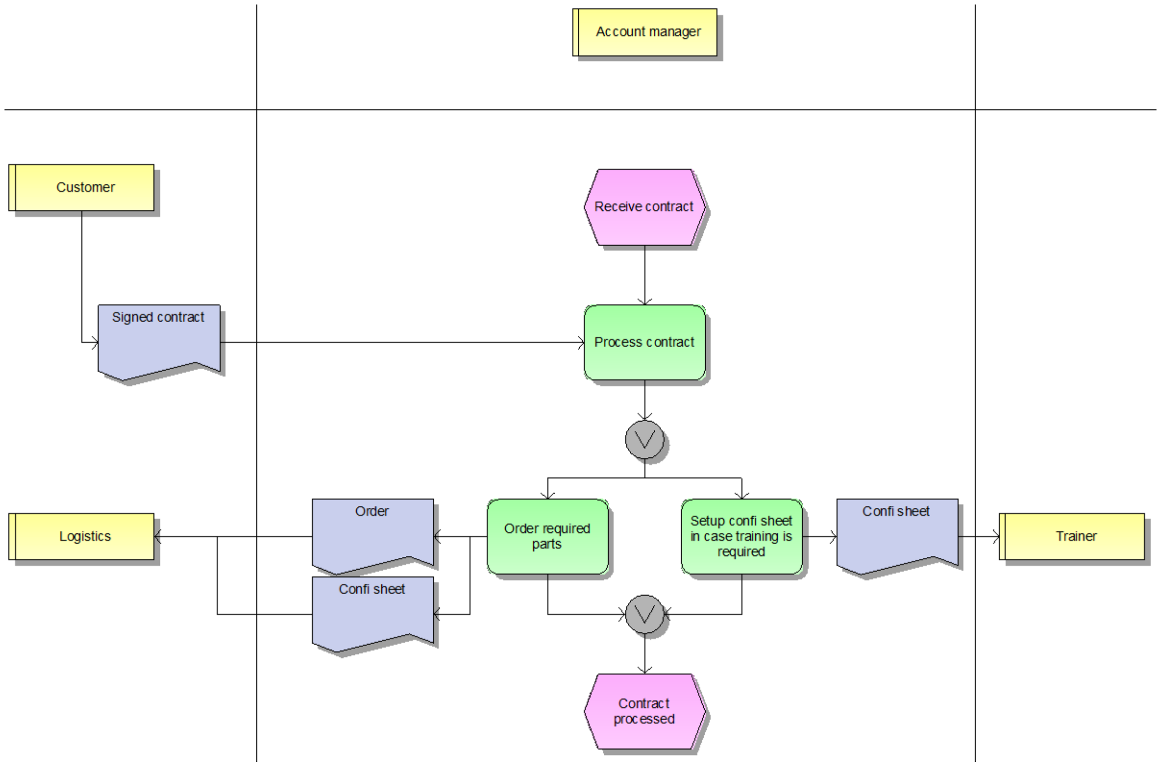
Appendix G: Training/installation Plural process model



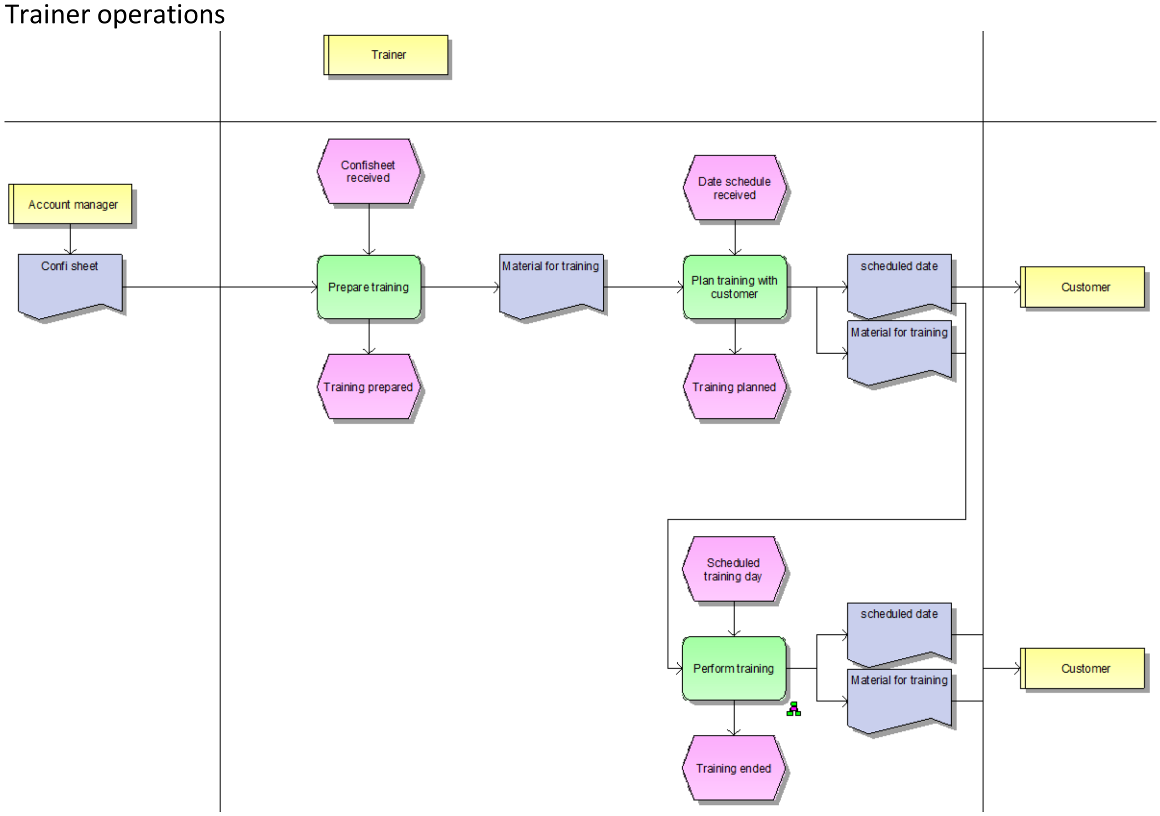
Customer operations

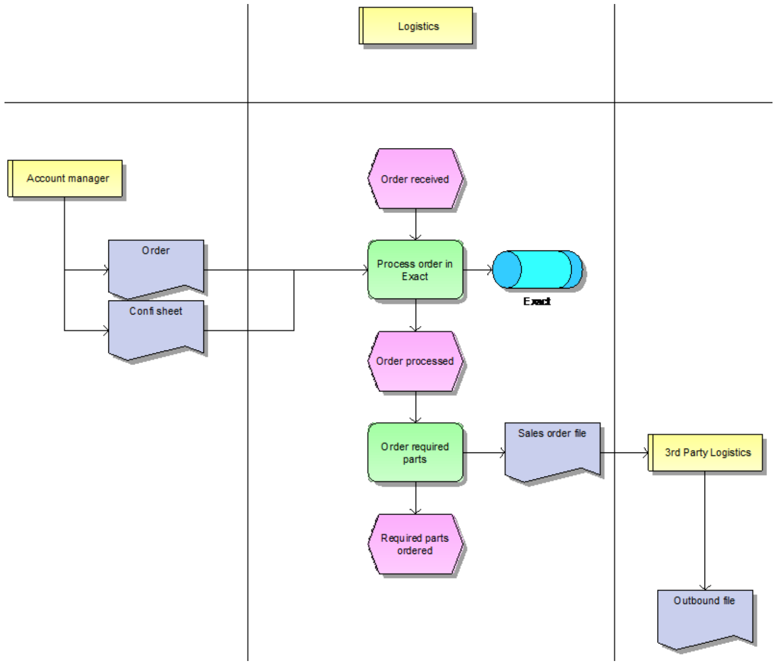


Account manager operations

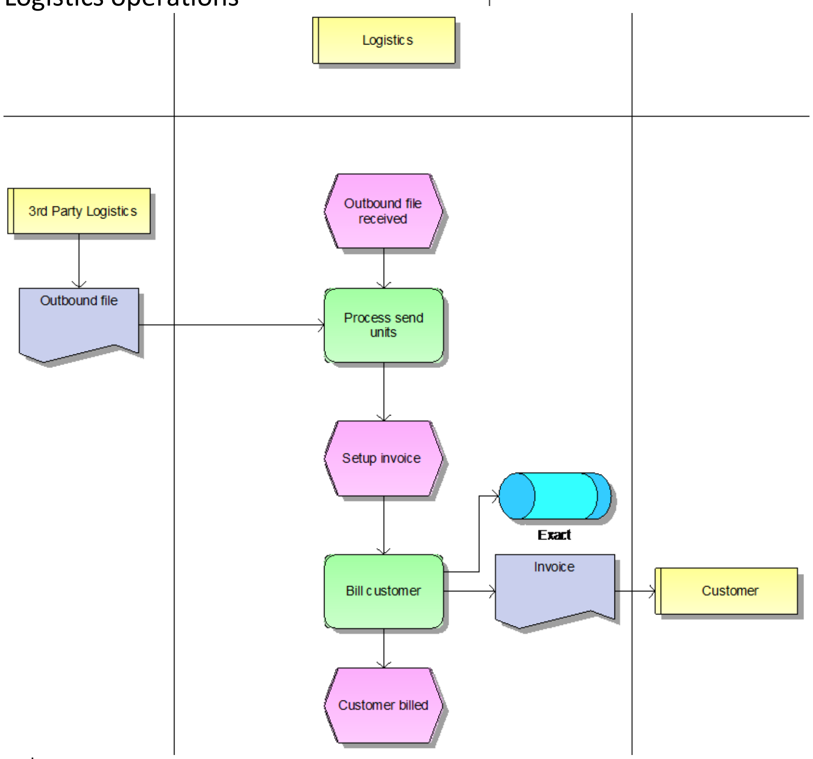


Trainer operations

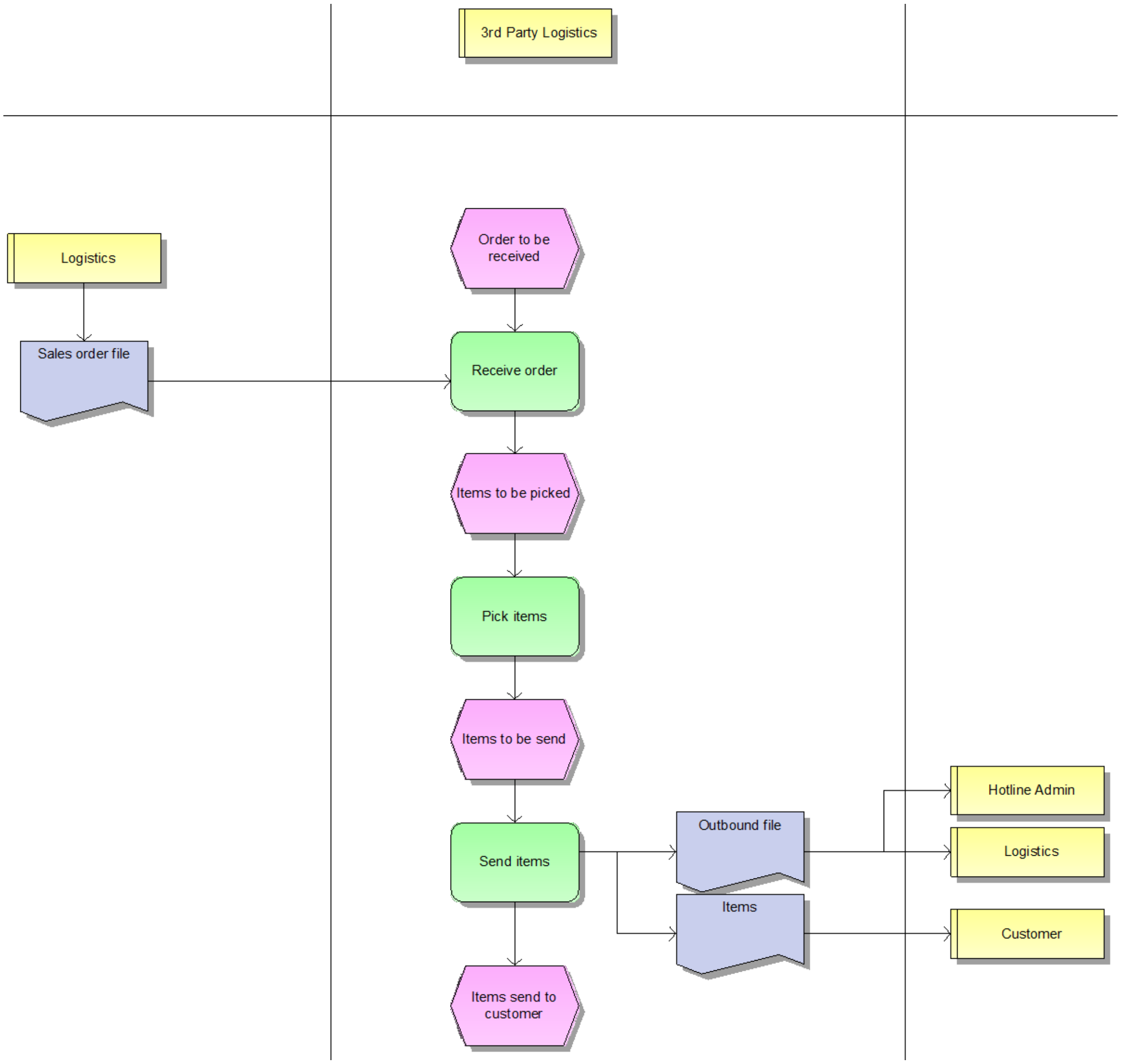




Logistics operations



3rd party logistics operations


3rd Party Logistics
Logistics
Sales order file
Order to be received
Receive order
Items to be picked
Pick items
Items to be send
Send items
Outbound file
Items
Hotline Admin
Logistics
Customer
Items send to customer

Appendix E: Questionnaire

Measuring the understandability of process models

Thank you for participating in this master thesis study about the evaluation of two different process models. The results of this study will give an indication whether the outcome of measuring these models will beneficially extent the field of business process management. The questionnaire consists of 28 questions divided into three parts which should take about 20 minutes to complete. Along with the questionnaire two models about the RMA process and the training/installation process will be provided. You will need these models in order to answer the questions.

The answers to the questions will be treated fully anonymously.

Start

www.thesistools.com

Measuring the understandability of process models

Part 1: Personal information, question 1-10

1.

1. How long have you been working for [redacted]?*

Years

2.

2. How long have you been working in your current position?*

Years

3.

3. What is your current position within [redacted]?*

4.

4. What is the highest level of education you have completed?*

- ◯None
- ◯Primary school
- ◯High school (VMBO, HAVO, VWO)
- ◯Associate or technical degree (MBO)
- ◯Bachelor degree (HBO)
- ◯Master degree (WO)
- ◯Other, namely

5.

5. What is your age?*

Years

6.

6. What is your gender?*

◯Male
◯Female

7.

7. Have you been interviewed by the researcher?*

◯Yes
◯No

8.

8. Are you directly involved in the RMA process?*

◯Yes
◯No
◯I do not know

9.

9. Are you directly involved in the installation/training process?*

◯Yes
◯No
◯I do not know

10.

10. The following statement measures your modeling experience. Your answer can be given on a scale, ranging from 1 ("Strongly disagree") through 5 ("Strongly agree").

	Strongly disagree				Strongly agree
I am very familiar with process models.	◯	◯	◯	◯	◯

Part 2: Use model 1 for question 11-19

11.

11. These questions relate to the understandability of the process model. Please indicate whether the answer to the question is "Yes", "No", or "I do not know". Please use model 1 for the following questions

	Yes	No	I do not know
a. Can the RMA only be cancelled when the customer disagrees on the agreement form?	○	○	○
b. Can the process be finished without invoicing the customer?	○	○	○
c. Can a customer receive more than one invoice during the process?	○	○	○
d. Does the customer receive a reminder when the broken part has not been returned within 30 days?	○	○	○
e. Does logistics close the RMA in CRM?	○	○	○
f. Does the Technical Support Specialist notify the customer in case a broken part had not arrived in time?	○	○	○

12.

12. The following question is about the perceived difficulty of the model. Your answer can be given on a scale, ranging from 1 ("Very simple") through 5 ("Very difficult")

	Very simple				Very difficult
Please rate the difficulty of the model on a 5-point scale.	○	○	○	○	○

13.

13. The following questions measure the intention to use. Your answers can be given on a scale, ranging from 1 ("Strongly disagree") through 5 ("Strongly agree")

	Strongly disagree				Strongly agree
a. If I retain access to this way of modeling, my intention would be to continue to use it for process modeling	○	○	○	○	○
b. In the future, I expect I will continue to use this way of modeling for process modeling	○	○	○	○	○
c. I would definitely not use this way of modeling to document large process models	○	○	○	○	○

14.

14. The following questions measure the perceived usefulness. Your answers can be given on a scale, ranging from 1 ("Strongly disagree") through 5 ("Strongly agree").

	Strongly disagree				Strongly agree
a. I believe that this way of modeling would reduce the effort required to document large process models	○	○	○	○	○
b. Large process models represented using this way of modeling would be more difficult for users to understand	○	○	○	○	○
c. Using this way of modeling would make it more difficult to maintain large process models	○	○	○	○	○
d. Overall, I think this way of modeling does not provide an effective solution to the problem of representing large process models	○	○	○	○	○
e. Using this way of modeling would make it easier to communicate large process models to end users	○	○	○	○	○

15.

15. The following questions are about the perceived ease of use (14-18). Your answers can be given on a scale, ranging from 1 ("Strongly disagree") through 5 ("Strongly agree").

	Strongly disagree				Strongly agree
a. I found the model confusing to use	○	○	○	○	○
b. Using the process model required a lot of mental effort	○	○	○	○	○
me					
d. Overall, I found the process model easy to use	○	○	○	○	○
e. Using the process model was frustrating	○	○	○	○	○

16.

16. Your answer can be given on a scale, ranging from 1 ("Not adequately") through 5 ("Very adequately").

	Not adequately				Very adequately
How adequately do you believe the process model meets the information that you were asked to support?	○	○	○	○	○

17.

17. Your answer can be given on a scale, ranging from 1 ("Not efficient") through 5 ("Very efficient").

	Not efficient				Very efficient
How efficient is the process model for providing the information you need?	○	○	○	○	○

18.

18. Your answer can be given on a scale, ranging from 1 ("Not effective") through 5 ("Very effective").

	Not effective				Very effective
How effective is the process model for providing the information you would need?	○	○	○	○	○

19.

19. Your answer can be given on a scale, ranging from 1 ("Not satisfied") through 5 ("Very satisfied").

	Not satisfied				Very satisfied
Overall, how satisfied are you with the process model for providing the information you need?	○	○	○	○	○

Part 3: Use model 2 for question 20-28

Appendix F: Statistics

Statistics

Group 1A2B or 1B2A			Workingyears	Positionyears	Position	Education	Age	Gender	Interviewed	RMAinvolved	Traininginvolved	Experience
Group 1A2B	N	Valid	11	11	11	11	11	11	11	11	11	11
		Missing	0	0	0	0	0	0	0	0	0	0
	Mean		5,09	3,27		4,82	37,91	1,27	1,82	1,55	2,00	3,27
	Median		4,00	2,00		5,00	35,00	1,00	2,00	2,00	2,00	3,00
	Std. Deviation		3,477	2,453		,982	7,204	,467	,405	,522	,000	1,272
	Minimum		1	1		3	29	1	1	1	2	1
	Maximum		12	8		6	49	2	2	2	2	5
Group 1B2A	N	Valid	10	10	10	10	10	10	10	10	10	10
		Missing	0	0	0	0	0	0	0	0	0	0
	Mean		5,70	3,20		4,30	36,60	1,40	1,40	1,20	1,80	4,10
	Median		4,50	2,50		4,50	34,00	1,00	1,00	1,00	2,00	4,00
	Std. Deviation		4,296	3,521		1,252	10,606	,516	,516	,422	,422	,738
	Minimum		0	0		3	25	1	1	1	1	3
	Maximum		12	12		6	63	2	2	2	2	5

Workingyears

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	1	1	9,1	9,1	9,1
		2	2	18,2	18,2	27,3
		3	2	18,2	18,2	45,5
		4	1	9,1	9,1	54,5
		5	1	9,1	9,1	63,6
		7	1	9,1	9,1	72,7
		8	1	9,1	9,1	81,8
		9	1	9,1	9,1	90,9
		12	1	9,1	9,1	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	0	1	10,0	10,0	10,0
		2	1	10,0	10,0	20,0
		3	3	30,0	30,0	50,0
		6	2	20,0	20,0	70,0
		10	1	10,0	10,0	80,0
		12	2	20,0	20,0	100,0
		Total	10	100,0	100,0	

Position

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	Administrative Services Coor	1	9,1	9,1	9,1
		HR Assistant	1	9,1	9,1	18,2
		IT Engineer	1	9,1	9,1	27,3
		Logistics specialist, senior	1	9,1	9,1	36,4
		MANAGING DIRECTOR	1	9,1	9,1	45,5
		Office Manager	1	9,1	9,1	54,5
		Senior technical support	1	9,1	9,1	63,6
		Sr Director Operations	1	9,1	9,1	72,7
		Staff HR Representative	1	9,1	9,1	81,8
		Technical Support Specialist	2	18,2	18,2	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	Admin Controller	1	10,0	10,0	10,0
		Buyer/planner	1	10,0	10,0	20,0
		Manager technical support	1	10,0	10,0	30,0
		Project Manager	2	20,0	20,0	50,0
		Senior technical writer	1	10,0	10,0	60,0
		Technical Support Specialist	4	40,0	40,0	100,0
		Total	10	100,0	100,0	

Education

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	High school	1	9,1	9,1	9,1
		Associate or technical degree	3	27,3	27,3	36,4
		Bachelor degree	4	36,4	36,4	72,7
		Master degree	3	27,3	27,3	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	High school	4	40,0	40,0	40,0
		Associate or technical degree	1	10,0	10,0	50,0
		Bachelor degree	3	30,0	30,0	80,0
		Master degree	2	20,0	20,0	100,0
		Total	10	100,0	100,0	

Positionyears

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	1	3	27,3	27,3	27,3
		2	3	27,3	27,3	54,5
		3	1	9,1	9,1	63,6
		4	1	9,1	9,1	72,7
		5	1	9,1	9,1	81,8
		7	1	9,1	9,1	90,9
		8	1	9,1	9,1	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	0	1	10,0	10,0	10,0
		1	3	30,0	30,0	40,0
		2	1	10,0	10,0	50,0
		3	3	30,0	30,0	80,0
		6	1	10,0	10,0	90,0
		12	1	10,0	10,0	100,0
		Total	10	100,0	100,0	

Age

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	29	1	9,1	9,1	9,1
		31	1	9,1	9,1	18,2
		32	2	18,2	18,2	36,4
		33	1	9,1	9,1	45,5
		35	1	9,1	9,1	54,5
		41	1	9,1	9,1	63,6
		43	1	9,1	9,1	72,7
		46	2	18,2	18,2	90,9
		49	1	9,1	9,1	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	25	1	10,0	10,0	10,0
		28	1	10,0	10,0	20,0
		32	3	30,0	30,0	50,0
		36	1	10,0	10,0	60,0
		37	1	10,0	10,0	70,0
		38	1	10,0	10,0	80,0
		43	1	10,0	10,0	90,0
		63	1	10,0	10,0	100,0
		Total	10	100,0	100,0	

Gender

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	Male	8	72,7	72,7	72,7
		Female	3	27,3	27,3	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	Male	6	60,0	60,0	60,0
		Female	4	40,0	40,0	100,0
		Total	10	100,0	100,0	

Interviewed

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	Yes	2	18,2	18,2	18,2
		No	9	81,8	81,8	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	Yes	6	60,0	60,0	60,0
		No	4	40,0	40,0	100,0
		Total	10	100,0	100,0	

RMAinvolved

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	Yes	5	45,5	45,5	45,5
		No	6	54,5	54,5	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	Yes	8	80,0	80,0	80,0
		No	2	20,0	20,0	100,0
		Total	10	100,0	100,0	

Traininginvolved

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	No	11	100,0	100,0	100,0
Group 1B2A	Valid	Yes	2	20,0	20,0	20,0
		No	8	80,0	80,0	100,0
		Total	10	100,0	100,0	

Experience

Group 1A2B or 1B2A			Frequency	Percent	Valid Percent	Cumulative Percent
Group 1A2B	Valid	Strongly disagree	1	9,1	9,1	9,1
		Disagree	2	18,2	18,2	27,3
		Neutral	3	27,3	27,3	54,5
		Agree	3	27,3	27,3	81,8
		Strongly agree	2	18,2	18,2	100,0
		Total	11	100,0	100,0	
Group 1B2A	Valid	Neutral	2	20,0	20,0	20,0
		Agree	5	50,0	50,0	70,0
		Strongly agree	3	30,0	30,0	100,0
		Total	10	100,0	100,0	