

Workflow improvement by artifact development

Bachelor Thesis
Industrial Engineering & Management
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Foreword

This research contains my bachelor's thesis "Workflow improvement by artifact development." This thesis was written in order to complete my bachelor Industrial Engineering and Management at the University of Twente. The research has been conducted at Boelsma Projectmanagement & Engineering B.V. located in Oldenzaal, The Netherlands. The research is about making the complete project planning process at the company more efficient. This is done by ways of integrating processes, automating different tasks and creating an artifact around that.

I would like to take this opportunity to thank my supervisors from the University of Twente, Maria Iacob and Adina Aldea for their guidance. They provided me with the guidance in selecting the best theoretical frameworks and solutions for the project. It really helped me to get a grip on what I was doing, what next steps to take and what direction to head for. The feedback sessions were always to the point, but never rushed, which made them work pleasant and efficient for me.

I would also like to thank my company supervisor, Alwin Boelsma for his guidance, support and feedback during the project. He showed me the complete business process from logistics and financials till the actual installations they deliver at customers. He provided precious insights and feedback during the project and was also always open to answer my questions.

Lastly, would I like to thank Thijmen Meijer and Bas van Tintelen, friends and fellow students of mine, for their support and feedback during the complete process of setting up the thesis till the completion of this thesis. They helped me greatly with grammatical feedback, giving advice on my plans and motivating me during the process of creating this thesis.

I hope you will find this thesis an interesting read.

Ruben Lucas, May 2020

Management summary

Due to the larger amount of projects BPE reaches a point in which they need to scale up their operations to keep up with demand. Before increasing the amount of staff BPE wants to look into possibilities to make their current workflow more efficient.

One of the largest and most time consuming parts of BPE's operations is the digital procurement and assemblage part. After analyzing this part of the workflow I found that the current software that is used for this operation causes that a lot of human labor is needed and that the current database system was not directly connected to the rest of the digital structure. This causes the procurement and assemblage workflow to be less efficient than that it potentially could be.

After a comprehensive potential solution consideration I landed on creating a new software artifact for the procurement and assemblage process in Excel with the help of VBA and SQL. VBA is a programming language integrated in Excel that that can be used to automate multiple tasks. Through VBA a SQL database can be connected to the artifact to preserve larger amounts of data.

With this software structure I created an artifact in which projects can be created, materials with all corresponding data can be saved, contact data can be saved, different prices can be saved for every material, order papers can be automatically created, material lists can be created in which material logistics and finances can be tracked and a complete financial project overview page can be viewed.

In this way I have created a setup for a solution that can make the procurement and assemblage workflow more efficient. For it to work perfectly however there is still further development required.

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Glossary of terms

In my bachelor thesis I used terms and abbreviations that may be unclear or misinterpreted by the reader. To avoid this, I created a list of definitions that can be found below.

ADO	ActiveX Data Objects technology is a data access technology that provides users the possibility to access data from a database.
Artifact	A software application that is designed and developed to perform a range of different functions, tasks, or activities for the benefit of the user.
Bottleneck	A situation that causes delay in a process or system.
BPE	Boelsma Projectmanagement & Engineering, the company at which this bachelor assignment was executed.
CRM	Customer Relationship Management is a category of software that covers a broad set of applications designed to help businesses manage many of the following business processes: Customer data, customer interaction, access business information, automate sales, track leads, contracts, marketing, customer support, clients and contacts, support vendor/partner relationships, employees, knowledge and training and assets or resources.
ERP	Enterprise Resource Planning is business process management software that allows an organization to use a system of integrated applications to manage the business and automate many back-office functions related to technology, services and human resources. ERP software typically integrates all facets of an operation — including product planning, development, manufacturing, sales and marketing — in a single database, application and user interface.
Foreign key	FOREIGN KEY is a key used to link two tables together. A FOREIGN KEY is a field (or collection of fields) in one table that refers to the PRIMARY KEY in another table. The table containing the foreign key is called the child table, and the table containing the candidate key is called the referenced or parent table.

Framework	A software framework is a structure intended to serve as a support for building a software application. It provides predefined functionalities which can be selectively changed by additional user-written code, thus providing already created application-specific software.
SQL	Structured Query Language is a domain-specific language used in programming and designed for managing data held in a relational database management system (RDBMS), or for stream processing in a relational data stream management system (RDSMS). It is particularly useful in handling structured data where there are relations between different entities/variables of the data.
VBA	Visual basic is a programming language intended to Automate processes and build applications. VBA is also integrated in Microsoft Excel which is used in the creation of the artifact.
Workflow	the sequence of processes that comprise a particular type of work from initiation to completion.

1 Introduction

In this chapter, I will give an introduction to my assignment at Boelsma Projectmanagement & Engineering. I will also provide some general information about Boelsma Projectmanagement & Engineering, hereinafter referred to as BPE.

1.1 Introduction to the company

BPE is a system integrator who delivers management, engineering and implementation services for the food, chemical and pharma industry. Projects are small (20k) up to medium sized (1m) and can differ from realization of a complete brewery to optimization of a malfunctioning production line. For all these projects a range of tasks have to be executed, depending on the scope of the project. These tasks are f.i.: Process design, budget calculations planning, civil engineering, mechanical engineering, budget control, procurement, material management, construction management, safety management, etc.

1.2 Motivation for research

At the moment BPE has the possibility to scale up the amount and/or size of the projects they take on at the same time, because of the increase in incoming project inquiries. However, BPE is with the current number of projects they take on already running into capacity problems. So, with the current circumstances it would be impossible for BPE to scale up and grow their operations. To increase the capacity of work that BPE can take on, they can increase the amount of staff or improve their current workflow and make it more efficient. BPE believes that there can still be a lot of time and effort saved by innovating the current workflow and thinks that this will be a cheaper and more effective option than hiring more staff. This is also why I will be focusing on improving the current workflow of the company during my assignment.

1.3 problem statement

My assignment that was given by my supervisor of BPE for this bachelor thesis is to research the procurement and assemblage workflow for shortcomings and bottlenecks. These parts of the workflow are thought of to have the highest potential of time and complexity improvement. It is also the largest part in the workflow and it is easiest accessible since it all takes place within the company and does not deal directly with other companies. Then it was my task to design with the current bottlenecks a more effective workflow. Then execute and/or deliver a better solution that be implemented into the workflow of the company. This action problem/main research question can be stated as follows:

<i>Action problem:</i>	<i>Innovate the current procurement and assemblage workflow and make the operations thereby more efficient and less human labor intensive.</i>
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1.4 Research questions

For the execution of the action problem, different knowledge question need to be answered during the research. These research questions adhere to the design science methodology that will be further described in chapter 2. Firstly, to make the workflow more efficient and less labor intensive as stated in the action problem there has to be looked at the areas in the workflow in which the biggest improvement can be made. That can be done by looking at the bottlenecks in the current workflow, because that is the area in which the most resources and/or time are lost. This can be stated as follows:

Knowledge problem: What bottlenecks are there in the current procurement and assemblage workflow of the company?

I want to solve the knowledge problem stated above by having an open interview with my supervisor about potential bottlenecks and by observing and analyzing the current procurement and assemblage workflow. For the modeling of the current procurement and assemblage workflow an appropriate modeling language has to be used. This leads to the following knowledge problem:

Knowledge problem: What workflow modeling language to use for the companies procurement and assemblage workflow?

I want to solve this knowledge question by doing a literature research, which can be found in chapter 4. If all bottlenecks are found by answering the previously mentioned knowledge questions, research has to be done into the most effective bottleneck to tackle in the procurement and assemblage workflow of the company. Researching this would make clear where the biggest bottleneck is located in the procurement and assemblage workflow and would therefore also be the area where the biggest improvement can be gained when improving that area. This can be stated as follows:

Knowledge problem: Which is the most impactful bottleneck that can be tackled?

I want to solve the knowledge problem stated above by also having an open interview with my supervisor about the found bottlenecks and observing the bottlenecks myself. In this way I want to look at which bottleneck would have the biggest potential to make the workflow more efficient but also at which bottleneck I would be able to resolve. With a bottleneck selected research needs to be done into potential solutions for the bottleneck. To find out what would be the most effective way to tackle the selected bottleneck. This can be stated as follows:

Knowledge problem: Which solutions are there to solve the chosen bottleneck?

I want to solve the knowledge problem stated above with a literature research and an open interview with my supervisor in the company and companies in the same position or branch. This is also done to look into how other companies have solved similar issues. When a list of

solutions have been made, a solution has to be chosen to be implemented. This results in the following question:

Knowledge problem: Which is the most effective and appropriate solution for the company?

To answer this knowledge problem stated above I also need an appropriate grading scheme to grade the different solutions. This is why I first need to answer the following knowledge question:

Knowledge problem: What is an appropriate grading scheme for selecting an effective and appropriate solution for the company?

This knowledge question will be answered by doing a literature research, which can be found in chapter 4. For grading the different solutions I will do an interview with my supervisor in which appropriate grading criteria are selected and grades are given to these criteria according to the selected grading scheme. At last, when the most appropriate solution is chosen for tackling the earlier chosen bottleneck. A design approach needs to be researched and created. This will provide a clear view on how the solution will function, look and be implemented into the current workflow. This can be stated as follows:

Knowledge problem: How can the chosen solution be integrated into the current workflow?

I want to solve the knowledge problem stated above by creating a new workflow as will be discussed further in chapter 2, creating several designs of elements and structures that will be required in the chosen solution and discussing the integration with my supervisor in an open interview. This will help in creating a fitting solution that is not missing important features. After all the knowledge questions are answered I start on creating and implementing the solution.

1.5 Deliverables

This research delivers a minimal viable product that can be implemented into the current workflow and is designed to deliver an efficiency gain. This is done by a comprehensive research into different solutions, which ultimately resulted in an artifact design and development. This artifact should deliver BPE the possibility to take on more projects without the need to hire more staff.

2 Problem solving approach

In this chapter, I will describe the framework and methodologies used in my research. I will also describe the design and structure of my research.

2.1 Theoretical framework

The main theoretical framework that is used as structure throughout this research is the design science research methodology (Peppers, Tuunanen, Rothenberger, & Chatterjee, 2007). This is an approach focused on the development and improvement of the functional performance of a software artifact. This is applicable to my research since the bottlenecks that will be established in chapter 3 will lead to a software artifact creation that will improve and remedy the found bottlenecks. The framework consists of six different steps: Problem identification, objectives of the solution, design and development, demonstration, evaluation and communication as can be seen below in figure 1.

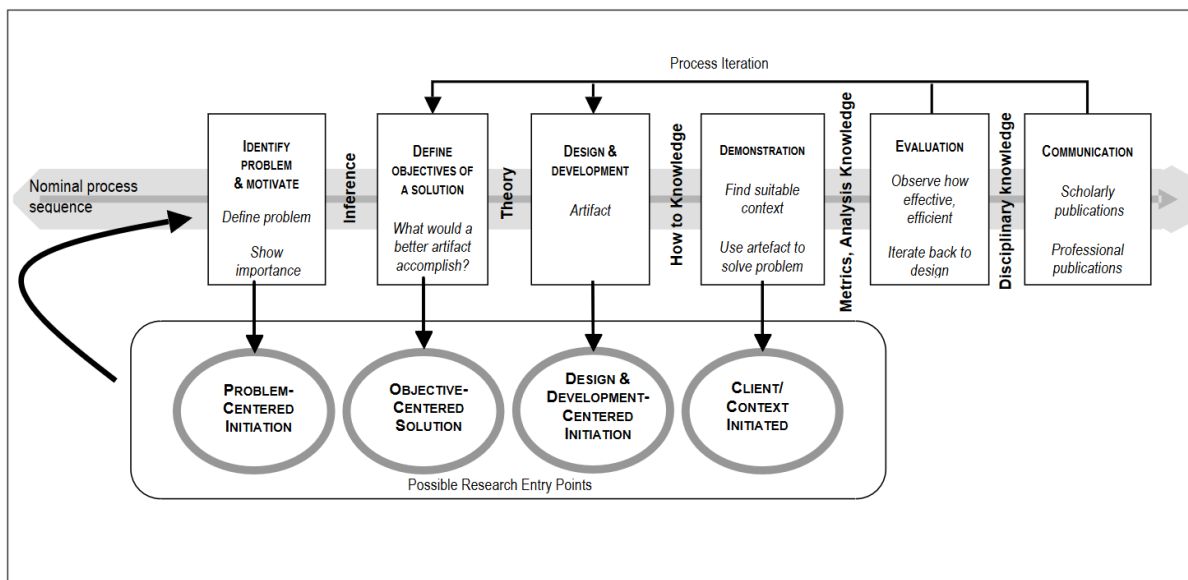


Figure 1: 6 step design science research methodology (Peppers et al., 2007)

2.2 Research design

To solve the knowledge problems and ultimately the action problem stated in chapter 1 I will map and describe how the 6 different steps used in the theoretical framework (design science research methodology) will be executed within my research together with other more step specific methodologies.

2.2.1 Phase 1: Problem identification

In the first step the problem identification needs to be executed. The problem identification will be done by analyzing and mapping the current procurement and assemblage workflow. I have chosen for this method since there is no clear problem indicated and through an analyses of the workflow can all parts of the company be evaluated.

For the analyses of the workflow I have used the workflow innovation methodology to give a clearer vision on the actions needed within this first step of the theoretical framework (van den Berg, Franken, & Jonkers, 2008). The workflow innovation actions can be found below in figure 2.

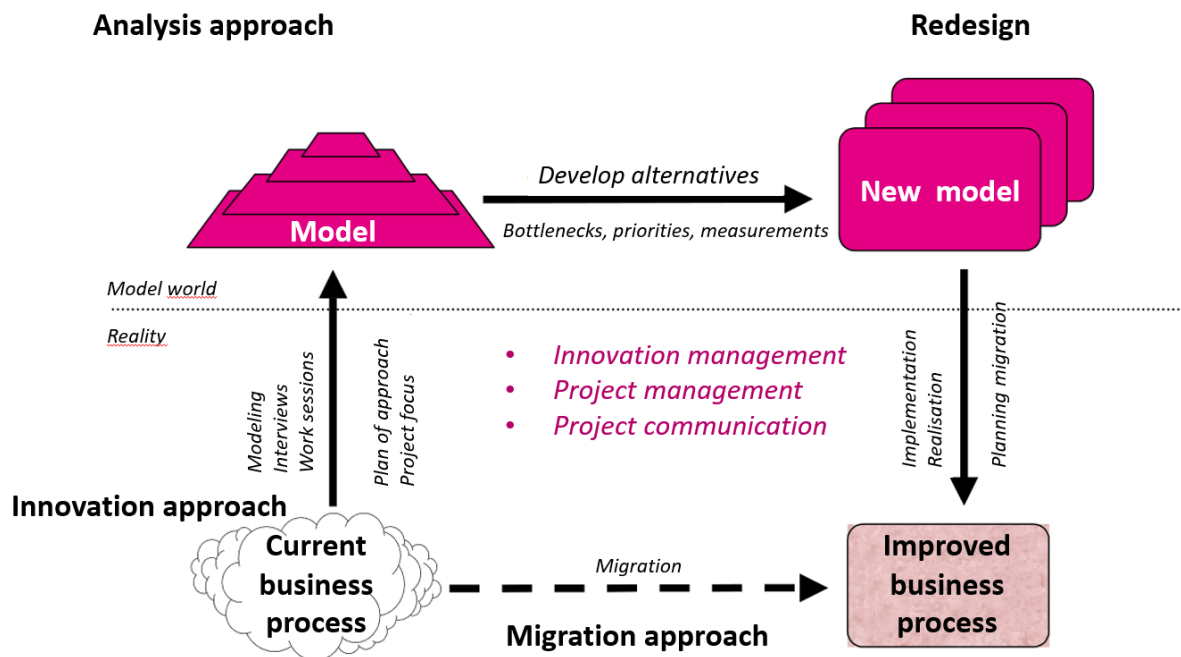


Figure 2: Workflow innovation methodology (van den Berg et al., 2008)

I used this methodology in narrowing down on my research area. For mapping my workflow and in finding appropriate improvement areas in the workflow. These steps can be found in chapter 3. The steps of the Workflow innovation methodology related to creating a new workflow are executed in phase 3. In this phase will the first three knowledge questions be answered. So, it will be clear what modeling language will be used to model the workflow, what bottlenecks are there in the current procurement and assemblage workflow and which is the most impactful bottleneck to tackle.

2.2.2 Phase 2: Objectives of the solution

In the second step the objectives for the solution have to be setup and an appropriate solution has to be chosen according to these objectives. The solution will be chosen according to AHP + TOPSIS method (Wątróbski, Jankowski, Ziemia, Karczmarczyk, & Ziolo, 2019). This is a Multiple-criteria decision analysis. In this phase will the fourth, fifth and sixth knowledge question be answered. So, different solutions will be selected and analyzed, the solutions will be graded and a solution will be chosen to be developed.

2.2.3 Phase 3: Design and development

In the third step has a design for the development be created. A new workflow is designed according to the workflow innovation methodology to make it clear how the artifact should be implemented (van den Berg et al., 2008). Next to that will a database design be created according to the entity-relationship model (ERD) notation (Song, Evans & Park, 1995). In this

phase will the last knowledge question be answered. So, it will be clear how the chosen solution can be integrated into the current procurement and assemblage workflow.

2.2.4 Phase 4: Demonstration

In the fourth step is the created artifact demonstrated and explained. An extensive user guide can also be found in appendix D: User instruction manual for the artifact.

2.2.5 Phase 5: Evaluation

In the fifth step is the created artifact evaluated. The artifact is evaluated according to the technology acceptance model (TAM) (Davis, 1989). This method accesses the perceived ease of use, perceived usefulness and attitude toward using the created artifact.

2.2.6 Phase 6: Communication

In the sixth step are conclusions drawn from this research. Herein are the found problem, research approach, artifact, relevancy to researchers and other relevant audiences discussed.

To see in which chapters which research phase is addressed, have a look at table 1 below.

Research phase	Chapters
1	3
2	5 & 6
3	7
4	8
5	9
6	10

Table 1: Research phase navigation

3 Current situation

In this chapter, I will give an overview of the current operations that take place in the company. I will do that by showing a model of the procurement and assemblage workflow and by describing all parts of the workflow that lie in my research area. I will also look into the bottlenecks of the current procurement and assemblage workflow of the company.

3.1 Research Area

To make analyzing the current workflow more approachable I focused on a specific research area. The research area that I focus on is the complete digital process of the company. This is the recording, management and storage of all digital processes that take place within the company.

I have chosen for this research area because the company especially stated that they think that this was the area that had the highest potential of an efficiency improvement. This is also overall the largest and most time-consuming aspect of the activities of the company.

3.2 Input, output and stakeholders

The input, output and people involved in the defined research area play an important part in the current workflow and are also taken into account in all parts of this research. I looked into the inputs, final outputs and stakeholders of a complete project to get a clear indication of the goal of the overall process. The inputs, outputs and stakeholders can be found below in figure 3.

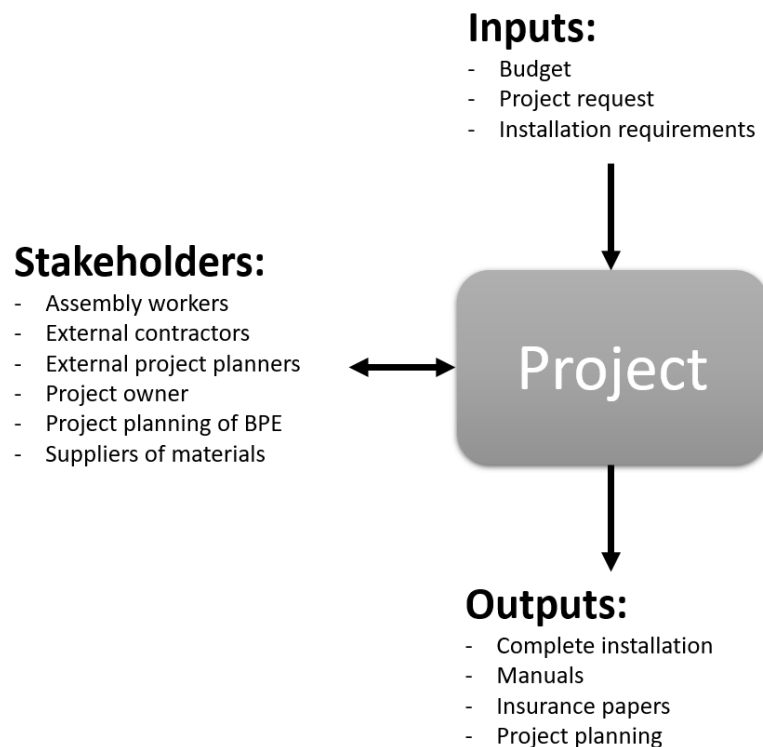


Figure 3: Input, output and stakeholders in a project

The inputs consist of a sufficient budget from the project owner to finance the execution of the project. This budget is mostly delivered into parts throughout the duration of the project, depending on the progress and needs of the project. A project request, which contains details and conditions about the installation that the project owner wants to get developed. The outputs consist of the complete installation that needs to be developed and created with the cooperation of all stakeholders.

3.3 Workflow model

To make the procurement and assemblage workflow more efficient, the current workflow has to be mapped first. This shows how all parts of the operation work together and go from inputs to outputs. It also gives a complete overview of all processes in the company. It will help in finding and deciding on the most impactful improvement possibilities. The workflow is mapped according to the BPMN method (White, 2004). Business Process Model and Notation (BPMN) is a graphical representation for specifying business processes in a business process model. The BPMN method has been selected to model the workflow according to literature research which can be found in chapter 4.2. The complete mapped procurement and assemblage workflow can be found below in figure 4. To get a better view at all the subprocesses have a look at appendix A: Current workflow models.

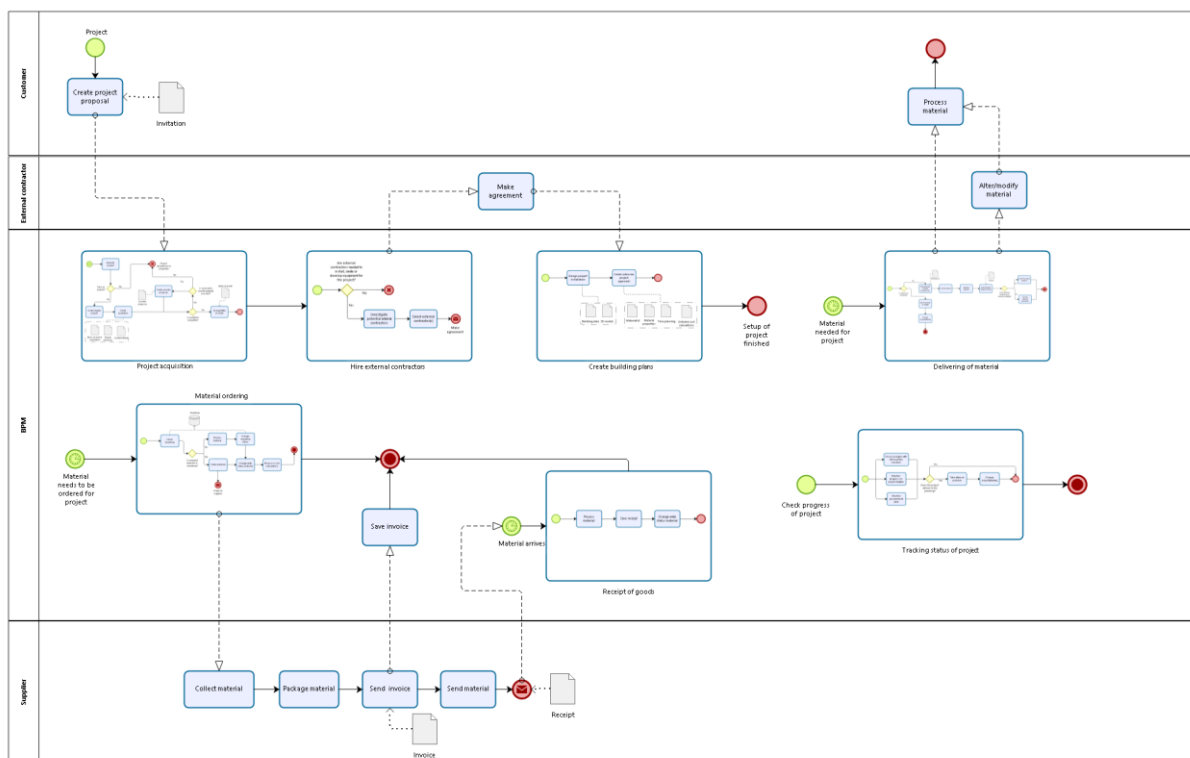


Figure 4: Current workflow of the company

The model starts off with a client/customer that has a project for which some type of project management or procurement is needed. The project owner will come to BPE with project plans, work that will need to be done by BPE for the project and a budget planning.

After the initial offer discussions and negotiations happen between the project owner and BPE to come to the final requirements of the project and a budget that will be available for BPE to execute the development and creation of the project. The project owner has the possibility to go to a competitor and let them execute the project, so BPE has to offer competitive conditions to get the project. It is also possible that only parts of the project are assigned to BPE and that BPE has to cooperate with other contractors in the execution of parts or even the complete project.

For the actual building, development and creation of the project external contractors are hired. These external contractors are often chosen collectively by BPE, the project owner and other contractors that are already involved. This is often done at the beginning of the project, so a time planning and material selection can be discussed with all parties that will be involved in the project. This prevents time planning's from not lining up correctly. It also helps in selecting the correct materials for the project, because the contractor that will work with the materials are already present and can give their advice on the selection.

The building plans consist of mapping the complete installation. This is done by creating models and drawings of how the installation will look and function. With the building plans is also a list of all required materials and a planning for the creation of the installation made. Selecting the materials and working out the required project realization activities is often done in collaboration with the project owner and other contractors involved. For the creation of the installation are activities such as building the installation, developing software systems and managing the project worked out.

One of the operations that is part of the building plans and will need to be executed for every project is a budget planning. A budget planning consists of prices for materials, building equipment and salaries. The prices for the materials are calculated according to historical prices. In the building plans is determined which materials are used and with prices of these materials out of previous projects is then a budget calculated for purchasing the materials. The salaries can consist of salaries for the workers that will build the installation, developers of digital control systems, project planners such as BPE and for any other person that works in some way on the realization of the project. These salaries are calculated according to the building plans. Hours are assigned for the completion of an activity in the building plans and with that the salary is calculated.

With the created list of materials and building plans there can be started on ordering the materials. These materials are ordered on the moment they are required in the project. In the order process need purchase orders, confirmation of orders, packing slips and invoices be processed and created. Materials get a label put on them with the tag number assigned to them in the building plans before being delivered to the location where the installation is build. This gives the workers the indication to where the material is needed. Later on it also gives the personnel working with the installation the possibility to easily look up all information about the material.

During the project it is important for BPE to track and monitor the progress of the project. So, if problems occur they can be quickly identified and resolved. It also helps in preliminary resolving problems. The monitoring is done by regularly discussing the progress with all people involved. It is also done by recording all activities and costs that are made. BPE does this precisely for every material. All price details are recorded, so finding the origin of an unexpected extra cost can be traced down to its exact origin. This helps BPE in better resolving problems, but also in preventing these unexpected costs from happening in the future.

3.4 Software model

To also get a better view of how all these events in the workflow correspond to the software that is used within the company I have created a software structure. This is needed because there are multiple software systems integrated within the workflow, which also play a large part in the total time and work spend throughout the workflow. This software structure is made with Archi, which is a modeling tool targeted towards creating enterprise models. Archi delivers a lot of options to model different software interactions and is therefore well fitted to create a software structure. I have created my model according to the Archi guidelines (The Open Group, Beauvoir & Sarrodie, 2019). The software structure can be found below in figure 5.

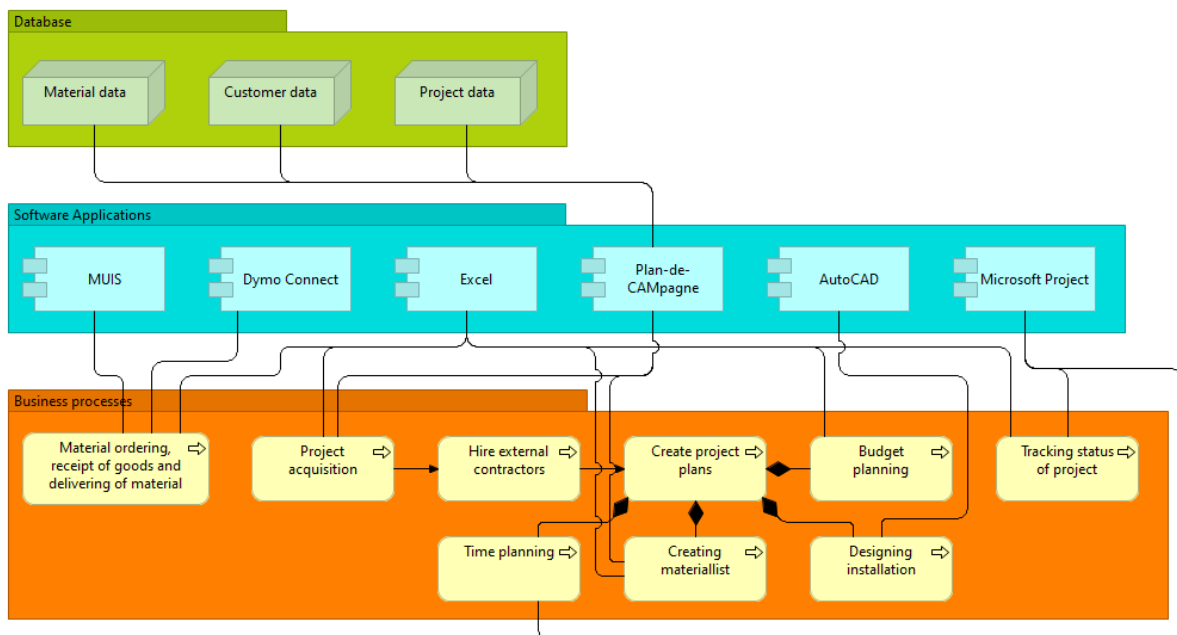


Figure 5: Current software structure of the company

Currently the company is using a range of different programs to execute the projects. AutoCAD by Autodesk is used for creating building plan models which show how the installation will function and be structured. Microsoft Excel is used for the logistics, material selection, budget planning, keeping track of all financials and for a part of the time planning creation. The ERP system Plan-de-CAMPagne was used before for all the tasks currently done in Excel, but is currently only used for supporting the Excel processes. Microsoft Project

is used for the creation of detailed project planning's and managing these planning's. iMuis is used for saving invoices. Lastly, Dymo Connect is used for printing labels for on the materials with a Dymo label writer.

3.5 Bottlenecks of software landscape

Out of analyzing the current procurement and assemblage workflow and discussions with my supervisor in the company I created a problem cluster with major points that obstruct an effective workflow and have a potential to improve the workflow substantially when resolved. This problem cluster can be found below in figure 6. The orange box in the middle displays the initial problem that needs to be resolved. This initial problem originates from the action problem stated in chapter 1. The blue boxes display causes of the initial problem. The green boxes display the sources of the problem.

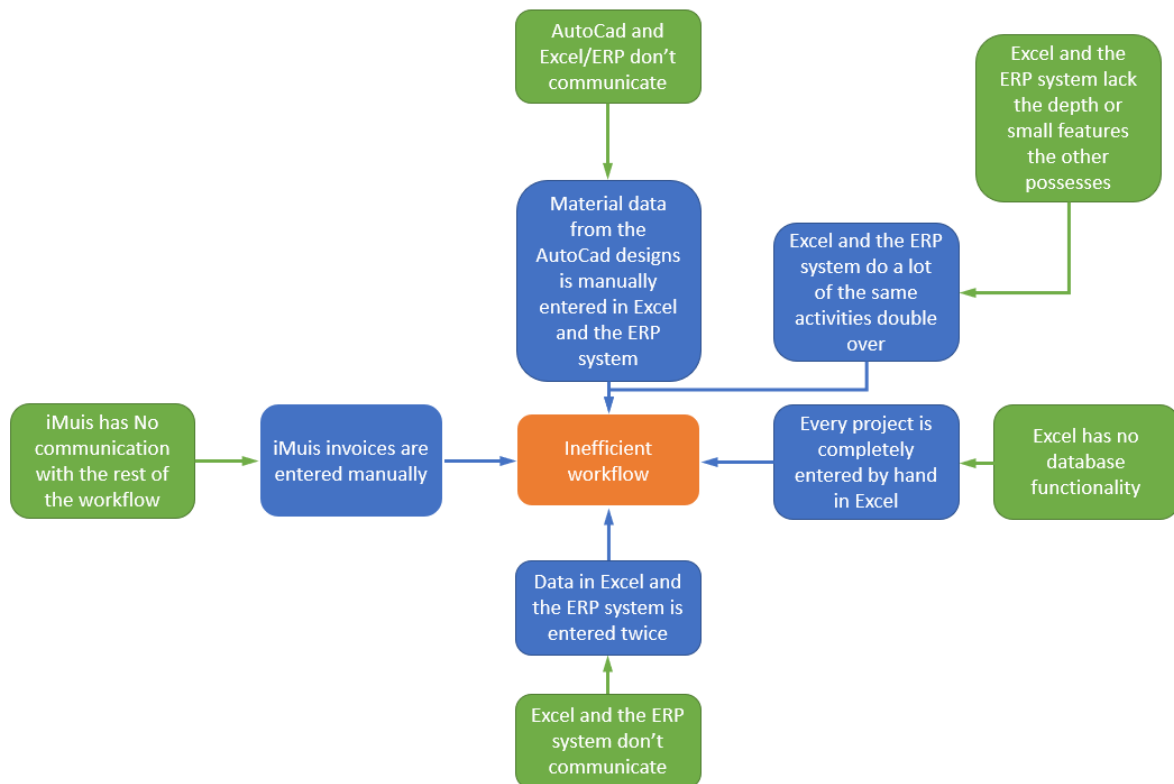


Figure 6: Bottleneck in the workflow

The green boxes are the sources of the initial problem and are therefore the core problems that need resolution. So, the first knowledge question can be answered: *“What bottlenecks are there in the current procurement and assemblage workflow of the company?”* The answer is the 5 green boxes displayed in figure 6:

- iMuis has no communication with the rest of the workflow
- AutoCad and Excel/ERP don't communicate
- Excel and the ERP system lack the depth or small features the other possesses
- Excel has no database functionality
- Excel and the ERP system don't communicate

Three of the improvement sectors are in integrating the different types of software with each other. At the moment a lot of data from one of the software platforms is entered in another software platform by hand, this requires a lot of human labor. Automating such a process would save a lot of time and human labor. Currently Excel and the ERP system take up the largest part of workflow activities done in a software package. So, tackling the bottlenecks “Excel and the ERP system don’t communicate” and “Excel and the ERP system lack the depth of small features the other possesses” together would have the biggest impact. So, the third knowledge question can be answered. *“Which is the most impactful bottleneck that can be tackled?”* The answer is: The workflow activities in Excel and the ERP system are not integrated with each other.

There are three ways to solve the just presented most impactful bottleneck, by integrating both software systems with each other, let one of the two software packages take over the tasks of the other system or use a new software system that can take over the tasks of both systems. In the next section I will look at the current problems according to both systems to get a better look at which possibilities there are in solving the selected bottleneck.

3.6 Shortcomings current platform

Excel and previously the ERP system Plan-de-CAMpagne are both platforms used by BPE for a lot of data recording and management activities. To better get an overview of why one of the systems is chosen instead of the other one and to get an overview of current problems with the software applications in the current procurement and assemblage workflow I looked into the shortcomings of both Excel and the ERP system Plan-de-CAMpagne. This helps me also in selecting the best areas to improve. After some hands-on experience with both platform I came up with the following shortcomings that can be found below in figure 7. The orange box in the middle displays the initial problem that needs to be resolved. This initial problem originates from the bottlenecks found in chapter 3.5. The blue boxes display causes of the initial problem. The green boxes display the sources of the problem.

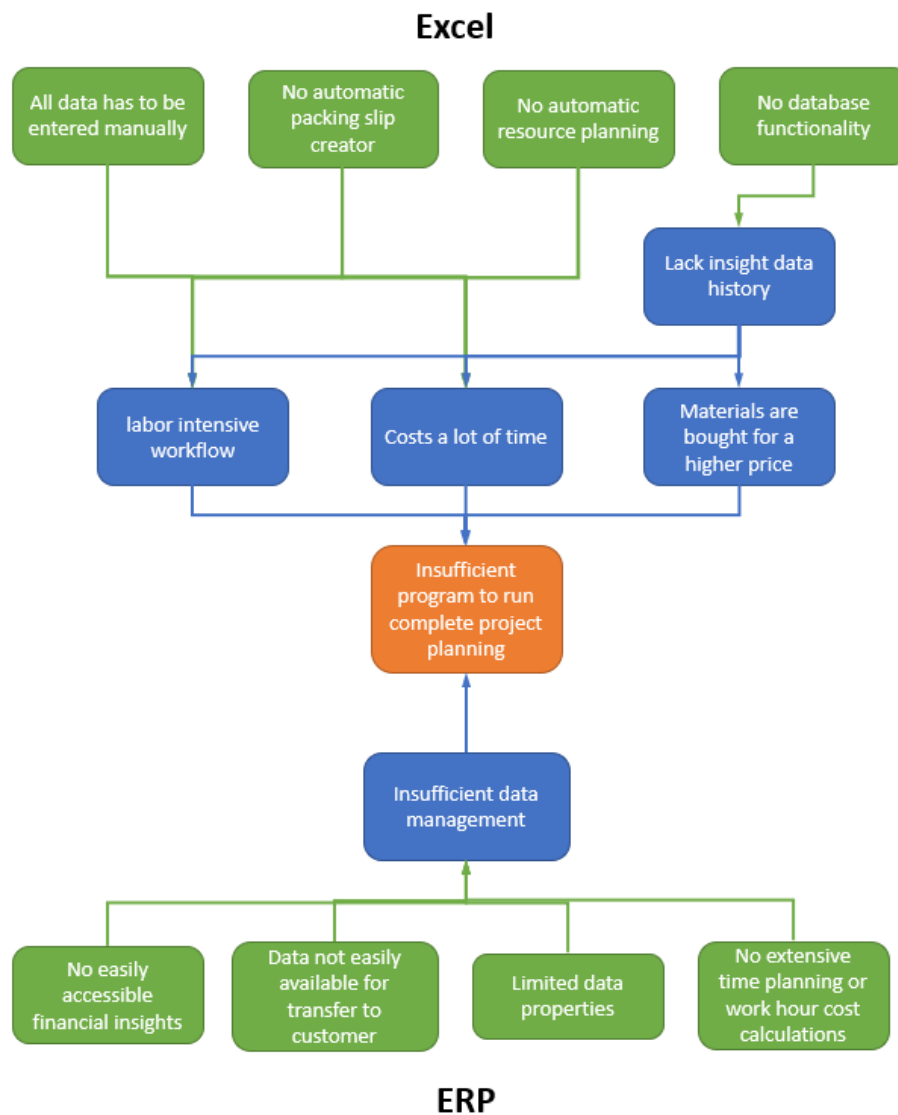


Figure 7: Shortcomings in Excel and the ERP system Plan-de-CAMpagne

The first problem in Excel is that it has no database functionality. Because of this it is only possible to manage a single project, it is not possible to combine excel files and a single Excel file would get slow and eventually unusable when they get big in file size. Without the possibility to combine projects you miss out on historical data from previous projects. For example, a supplier that delivers a certain product for a certain price in a previous project isn't remembered for a new project. This can lead to buying products for higher prices than necessary at stores from competitors. A lot of price negotiations happen in this business, so it is also not possible to just compare prices from webshops. You can look at previous Excel files to track down this info, but this takes a lot of time. The second problem with Excel is that a lot of data needs to be entered manually. All materials and their respective properties have to be entered by hand every time. Entering all this data costs a lot of time and human labor. The third problem with Excel is that it doesn't have a feature to create packing slips automatically. Creating these packing slips every time costs a lot of time and human labor. The last problem with Excel is that it has no automatic resource planning. So, all invoices, delivery statuses and the planning of the orders have to be done by hand. This again

requires a lot of time and human labor. Summarized are the biggest problems with Excel that a lot has to be done by hand which requires a lot of time and human labor, which then makes the total workflow fairly inefficient.

The first problem with the ERP system is that there is no easily accessible financial insight into how the project was doing according to the made budget. It takes multiple steps to get the info you need. The data visualization of the program was bad in this aspect. The second problem is that data is difficult to transfer to correctly formatted files which could be send to customers. The third problem with the ERP system is that it was restrictive in the amount of data you can enter. You could only enter predefined material properties and data categories which decreased the richness of the data. The last problem with the ERP system is that there is no possibility to enter prices for work hours. Materials have to be assembled and/or installed which is done by external organizations and because of that has to be accounted for in the project planning.

Since a lot of the problems with both platforms could be established I will be looking into potentially solving these issues in the solution chapter, which is chapter 6.

4 Literature research

In this chapter I will look at which possibilities get yielded by the literature to answer three of my knowledge questions. These knowledge questions consist of looking for an appropriate workflow mapping notation, searching for different bottleneck solutions and looking for an appropriate artifact scoring system.

4.1 General Inclusion and exclusion criteria

For all searches done in the literature reviews found in this chapter I used Scopus, because this search engine gives the most search options and gives therefore the possibility to get the most appropriate articles. For the articles I only looked at English and Dutch articles, because I'm not familiar with other languages. There is also no reason to believe that articles in other languages should contain info which would not be present in English or Dutch articles.

4.2 Workflow mapping notation

To model the procurement and assemblage workflow of the company an appropriate workflow modeling language has to be selected. That is why I will try to answer the following question in this literature research that is also stated in chapter 1:

What workflow modeling language to use for the companies procurement and assemblage workflow?

4.2.1 Inclusion and exclusion criteria

For the searches in this specific literature research I have chosen to look at the subject areas Computer science, Engineering, Business, management and accounting and Decision sciences. The subject area Computer science is related because the model is of a workflow with a lot of integrated digital parts. The subject areas Engineering, Business, management and accounting and Decision sciences were selected because they are related to a workflow consisting of business processes and decisions. I have chosen to look at articles after 2000, since there is no reason to believe that older methods won't be relevant. However, articles older than 20 years without newer literature released about the subject would most likely not be suitable because the subject area is a relevant topic where a lot of literature should be present about and could present a lot of outdated data and conclusions.

4.2.2 Way of searching

In my first search I looked for a comparison of different workflow mapping notations to find the most fitting one. I did this by using general terms that describe a workflow mapping notation together with the comparative term. After that I looked with my second search into an overview of the workflow mapping notation that was the result of the first search. This is BPMN as will be further explained in section 4.2.3. That is why I used that as my search term in the second search. The goal of this search was to get a description of how the workflow

mapping notation functioned. All search terms used can be found below in table 2.

Nr.	Search engine	Search terms	Search date	Articles found	Articles used
1	Scopus	<i>TITLE-ABS-KEY(Business AND (Process OR Event) AND ((Notation) OR Language) AND Model AND (Review OR Study OR Analysis) AND Comparative) And ALL((Visual OR Graphic))</i>	09-06-2020	10	2
2	Scopus	<i>TITLE-ABS-KEY(Business AND Process AND Modeling AND Notation AND BPMN AND Overview)</i>	09-06-2020	27	1

Table 2 : Search entries – Workflow mapping notation

4.2.3 Comparison of mapping notations

In the literature I found multiple different workflow mapping notations compared to each other on multiple different criteria. The workflow mapping notations that were compared: UML-AD, eEPC, BPMN, PROMOTE, Oliveira and KMDL 2.2. All notations were scored with different criteria on functional, organizational, behavioral, informational, intentional and knowledge perspective. The paper has chosen BPMN as the most suitable notation. The most important reasons why BPMN was chosen is because it is the most used, easy to use, understandable, expressive, has a richness of concepts and it is grounded on experience of older mapping notations (Ben Hassen, Turki, & Gargouri, 2017). BPMN is also the only mapping notation out of the selection that I have worked with before in multiple other project on the university and is therefore all the more suitable.

4.2.4 Usage in research

For the mapping of the workflow I will be using the business process model and notation (BPMN) standard as discussed in the previous section. In the workflow modeling I will adhere to the notation standards setup (White, 2004). I will be using the software application Bizagi process modeler to model the workflow in. Bizagi is chosen because according to the literature it is widely used to model workflows and it implements the BPMN standard (Maqbool et al., 2018). Bizagi is also the application that I have modeled workflows according to the BPMN standard with in other projects on the university, which makes it all the more suitable.

4.3 Bottleneck solutions

To solve the analyzed bottlenecks from chapter 3, the workflow activities in Excel and the ERP system are not integrated with each other, different solutions have to be researched. This will be done as discussed in chapter 1 with different research methods, but here I will look at the question according to the literature. The knowledge question as stated in chapter 1:

Which solutions are there to solve the chosen bottleneck?

The goal of this knowledge question is to get a clear overview of software applications that can be used for the creation of the overall project application. This is related to the platforms named in the bottleneck, but also new platforms could be researched for this.

4.3.1 Specific inclusion and exclusion criteria

For the searches in this specific literature research I have chosen to only look at the subject areas Engineering, Computer science and Business, management and accounting. I have chosen for these subject areas because these capture the goal of the research the best, because the research is about finding a software solution. I have also chosen to only look at articles after 2010, because software develops quickly and software older than ten years would not be sufficient for this project.

4.3.2 Way of searching

I defined different search terms to search for all different types of software solutions. These search terms are based on all information already gained out of the research, but also on knowledge gained at the university at previous projects. For the first search I looked at more general literature. I did this by using general search terms that are related to the my research. That is why I have used terms found in the action problem and problem solving approach that could lead to an appropriate solution. For the second search I wanted to look at more fast development based solutions. I did this since the first search result returned info about prebuild solutions and because in earlier projects at the university I had worked with such development tools like Mendix. For the third search I wanted to look if there were ways to make the current software platform used by the company viable. I did this by using the software Excel together with the search term database, since that was the functionality missing. I also added visual basic since that is the programming language integrated in Excel that is used to develop complex functions in Excel. For the fourth search I wanted to look at solutions build from the ground up by code and if they would be able to be used for this project. I added the terms lightweight, small, model and web to make the search more focused on platforms that would be able to quickly develop applications. All search terms used can be found below in table 3.

Nr.	Search engine	Search terms	Search date	Articles found	Articles used
1	Scopus	<i>TITLE-ABS-KEY("software" AND "business" AND "procurement") AND ALL("service" AND ("IT" OR "ICT") AND "application")</i>	25-05-2020	43	2
2	Scopus	<i>TITLE-ABS-KEY("model driven development" AND "application") AND ALL("fast" AND "code" AND "tool")</i>	26-05-2020	33	2
3	Scopus	<i>ALL("Excel" AND "development" AND "database" AND " visual basic")</i>	26-05-2020	55	1
4	Scopus	<i>TITLE-ABS-KEY("development" AND "application") AND ALL("code" AND "lightweight" AND "small" AND "model" AND "web")</i>	27-05-2020	69	1

Table 3: Search entries – Bottleneck solutions

4.3.3 ERP software

A ready-made software solution that a lot of businesses use is an Enterprise resource planning system. ERP systems are widely used for all kinds of digital tasks, among which procurement. There are a lot of different types of ERP systems with different types of structures and pricing arrangements (Mital, Pani & Ramesh, 2014). It is important to select an ERP system that is able to fulfill the objectives of the business, since there is often limited adjustability in the features of the chosen ERP system. That is why it is important to make a formulation of evaluation criteria and judge the ERP system against it (Poon & Yu, 2010).

4.3.4 Low-code platforms

There is also the possibility to create software myself. Creating a large scale software system from the ground up is however an extremely time consuming task. Although, currently the industrial sector shows an orientation towards low-code development platforms (Bernaschina, Comai & Fraternali, 2018). Low code is a form of software development that focuses on the visual design of applications. This is different from the traditional writing of computer code to create software. These platforms can be used to create tailored software in a fast and efficient manner. Another advantage is that it is cost efficient and easier to maintain than traditional software (Olariu, Gogan & Rennung, 2015). Examples named by the literature are Mendix, TrackVia, Outsystems and WebRatio.

4.3.5 Code based solutions

With Microsoft visual basic programming (which is integrated in Excel) it is possible to design a graphical user interface GUI along with MySQL as the database for data storage (Thaisongkroh & Rattanasiriwongwut, 2018). This would be a solution to fix the bottlenecks currently found with Excel in the workflow of the company. The last solution that came forward in the literature was using a lightweight, easy to learn and use framework that aims to reduce development time (Singh, Chawla, Singh & Singh, 2018).

4.3.6 Conclusion

A lot of different types of solutions were found in the literature. Using an ERP systems, which is currently also done by various companies to manage their digital tasks. Creating an artifact with a low-code platform that helps you build an application on the basis of model driven development. Link a database to the current Excel workflow with the help of VBA. Using frameworks to make the programming of an artifact easier and faster.

All these different platform have to be researched further and tested to see if they are viable for the creation of the previously defined project planning application. I will look further into every platform mentioned in this literature research. I will also discuss the found platforms with my supervisor in the company and some other competitors to get there opinion on the different platforms and to look for more potential solutions.

4.4 Artifact scoring scheme

To select the most appropriate solution a method to grade the different solutions has to be selected. I will be looking for an appropriate grading scheme in this literature research. That is why I will answer the following knowledge question as stated in chapter 1:

What is an appropriate grading scheme for selecting an effective and appropriate solution for the company?

According to the methodology discussed in chapter 2 I will be grading the solutions according to a MCDA. In this literature research I want to specifically look at the most appropriate MCDA method.

4.4.1 Inclusion and exclusion criteria

For the searches in this specific literature research I have chosen to look at the subject areas Computer science, Business, management and accounting and Decision science. I have chosen these subject areas because the search is related to a decision method often done for business purposes. Other subject areas would only lead to specific execution of such a method in a not concerned subject area. I have chosen to look at articles after 2000, since there is no reason to believe that older methods won't be relevant. However, articles older than 20 years without newer literature released about the subject would most likely not be suitable because the subject area is a relevant topic where a lot of literature should be present about and could present a lot of outdated data and conclusions.

4.4.2 Way of searching

In my first search I searched for an analysis of different MCDA methods, so I could have a clear overview of which method would be useful and be a good fit. For the second search I looked for an execution of the chosen MCDA method, which was AHP + TOPSIS. The search terms used can be found below in table 4.

Nr.	Search engine	Search terms	Search date	Articles found	Articles used
1	Scopus	TITLE-ABS-KEY(Multi-criteria AND Decision AND Analysis AND MCDA AND Method AND Selection AND Framework)	10-06-2020	16	1
2	Scopus	TITLE(AHP AND TOPSIS AND NOT Fuzzy) AND TITLE-ABS-KEY((Analysis OR Overview OR Study) AND software)	10-06-2020	6	1

Table 4: Search entries – Artifact scoring scheme

4.4.3 AHP + TOPSIS

From the MCDA method analysis found in the literature I came out on the AHP + TOPSIS method (Wątróbski et al., 2019). In this literature are 56 different MCDA methods compared to each other. I have chosen for the AHP + TOPSIS method because of multiple reasons. Firstly, this method supports weights for criteria. This will enable me to give different criteria a different level of importance. Secondly, this method uses relative weighting. So, the weights are established by comparing the importance of the criteria against each other. This is a way to compute the importance of different criteria. Thirdly, this method scores the solutions separately on the criteria instead of also grading the solutions relative to each other. I have chosen to score the solutions separately because then the different solutions don't influence each other's scores and new solutions can easily be added later on. Lastly, I have chosen to not use uncertainty in my analysis since this would make the analysis a lot more complex. The different steps of the AHP + TOPSIS method can be seen below in figure 8.

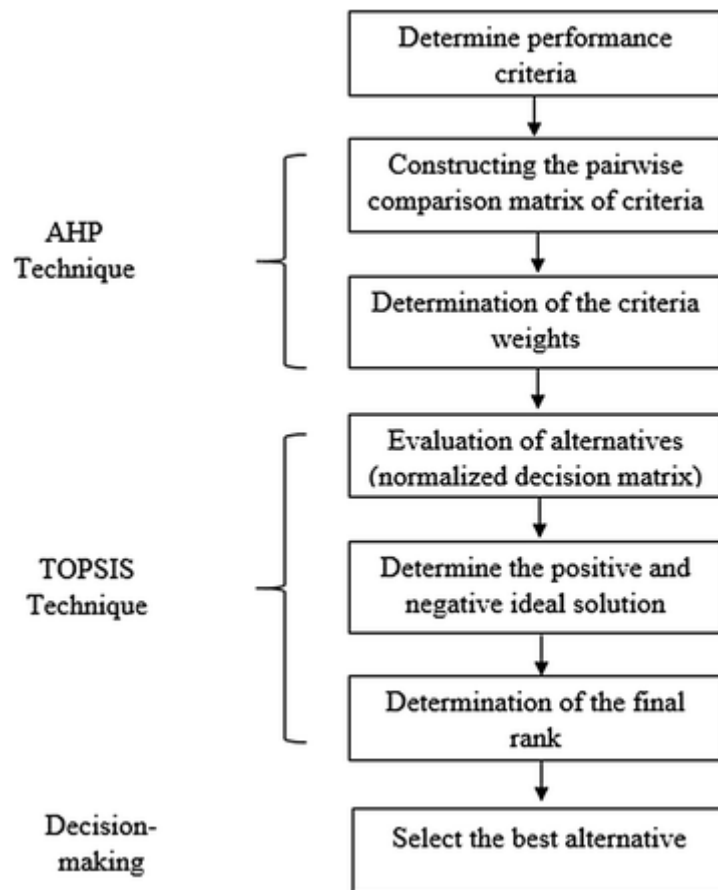


Figure 8: AHP + TOPSIS method overview (Hanine, Boutkhoul, Tikniouine, & Agouti, 2016)

In the first part of the AHP + TOPSIS method the different criteria have to be setup. Next will the criteria be compared relatively to each other. According to the AHP technique this will be done with a nine-degree scale. This scale describes how many times one variant is more important than another one. With all criteria established on this scale the final percentage weights can be calculated. Then the TOPSIS technique takes over in scoring the different solutions. Here all different solutions will be scored on a five-degree scale on how well they fulfill the given criteria. With all solutions scored on every criteria the final ranking can be calculated. The solution with the highest score will be the best alternative that comes out of the decision making. The execution of this method can be found in chapter 6.

5 Requirements for the solution

In this chapter, I will give an overview of all the requirements the solution to the bottleneck has to adhere to.

5.1 Background

I set up requirements for the potential solution so it is clear and can be confirmed that the solution would be suitable and effective for making the current workflow more efficient. These requirements are set up according to an interview with the supervisor of the company. In this interview where the tasks that are currently done in Excel and the ERP system Plan-de-CAMPagne considered and a list of final requirements created for a new solution. This was done because improving these tasks would have the biggest impact on the current workflow as described in section 3.5.

5.2 Requirement list

The list of requirements that the solution has to adhere to can be found below:

- The solution must be able to create a comprehensive material list which within different stages of the project can be created
- The solution must give insight into every detail of the financial expenses. Such as Material costs and salary/activity costs.
- The solution must be able to create a budget planning for both materials and salaries.
- The solution must be able to manage the logistics of materials. Show when materials need to be ordered, which materials need to come in and which materials are delivered.
- The solution must be able to create purchase orders, confirmation of orders, packing slips and invoices.
- The solution must be able to create projects.
- The solution must be able to record and manage contact details.
- The solution must be clearly structured and easy to use. In a maximum of two weeks of training should it be possible for an employee to work with and understand the platform on a basic level.

6 Inventory of alternative solutions and selections

In this chapter, I will look at different solutions that are available to satisfy the established requirements and therefore solve the problems found in the current workflow. From these found solutions will then a final solution be chosen according to different criteria.

6.1 Solution generating

For finding a solution to the bottleneck selected in section 3.5 I used the requirements created in section 5.2. The requirements don't necessary have to be covered by a single software application and can be satisfied by multiple different software applications that are linked. However, a combination of multiple software solutions often causes extra steps or extra work to create a functional connection, that is why I mostly looked into single software application solutions. I also tried to cover a wide range of different types of solutions, from already pre-build applications to development platforms which provide the tools to build a custom application.

The investigation into possible solutions was done by literature research, conversations with my BPE supervisor and conversations with competitors. The literature research was done in chapter 4. The two competitors that I talked with also did business in project management, but for different branches than BPE. Both competitors where of a larger size than BPE and where situated in the Netherlands. The competitors told me about their experience with the platform, the positives and negatives they encountered. They also showed of how they had implemented the software and all functionality they had achieved with the software. The platforms that I got to see at competitors where Zoho and Plan-de-CAMPagne V5.

6.2 Solutions

I will now discuss the platforms that were selected by me and analyzed as potential platform. These platforms where selected by literature research, which can be found in chapter 4, an open interview with my supervisor about potential solutions and the open interview done with the two competitors. This list is also an answer to my fourth knowledge question, "*Which solutions are there to solve the chosen bottleneck?*" Below can be found a list with all platforms and information about the platform.

- ERP Plan-de-CAMPagne V5

I looked at the newest version of the ERP software that the company already has used. I wanted to see if the shortcomings of the ERP software were fixed and if the platform would deliver a complete and more efficient option than their current workflow in Microsoft Excel. The version that BPE used before was the V4 version of the software and this version was already six years old. I investigated the program by discussing the possibilities with a contact person in the company that develops the ERP software. I also looked at how the newest

version of the ERP software was integrated in a company that already was working with the software.

- Microsoft Excel in combination with SQL

I looked at the possibility of making the current workflow in Microsoft Excel more efficient and I looked at ways to fix the shortcomings. It was clear that a database system was required to remedy the shortcomings. Without a database it would be impossible to transfer info between projects, which limits the possibilities of automating the workflow in Microsoft Excel drastically. After an investigation I found that through visual basic (vba), which is a programming language integrated in Microsoft Excel, it is possible to communicate to a database with the ADO library. The ADO library is a data access technology that provides users the possibility to access data from a database. More information about the working of visual basic and the ADO library can be found in chapter 8. By using the ADO library in combination with visual basic it would be possible to remedy the current shortcomings with the workflow in Microsoft Excel and make the workflow more efficient.

- Mendix

Mendix is a business process automation development platform. Mendix makes it possible to model processes according to a BPMN model and create processes and support it with a SQL database just like with Excel. Mendix however provides an intuitive low-code development platform. This makes it possible to quickly and more easily build applications that automate business processes and make the overall workflow more efficient. This low-code platform however also makes the development more restrictive than a coding based development because it offers a limited set of design options to build instead of the almost endless and more complicated code based designs that are possible.

- Zoho

Zoho is a customer relationship management (CRM) software package. It offers a range of different applications that cover all kinds of operations in the company. Next to these predeveloped applications is it also possible to modify these applications or even build applications from the ground up. This can be done by using the zoho builder, which works similar to Mendix. It is however less feature rich than Mendix. Next to this builder has Zoho also the possibility to develop and modify applications with a code based development platform, this is called Zoho deluge. This is a simple and barebone coding platform. Totally offers Zoho a lot of predeveloped features but also provides the possibility to change these features or even build features from the ground up.

- Full development with a framework

I looked at coding and developing a complete application from the ground up. This can be done by developing an application with a framework, which is a platform for creating and delivering software applications. Programming an application from the ground up will require a lot more work than any other option mentioned but will also provide the most customizability. This option will be judged on how an average full development framework

would score. If this option would result in the best scoring solution, more research will be performed in which specific framework would best fit the development of the application.

- Spendmap

SpendMap is a web-based software package that automates the entire purchasing process. It has different well-structured and clear modules for managing the requisitions, the purchasing department, the receiptment of goods, the approval of invoices, the inventory and the assets. In all these departments it is an easy to use and complete package, however it lacks some functionalities. It is only build for the receipt of goods and not for selling and sending of goods to clients. It also has no possibility to create and manage material lists and building activity lists. Therefore, Spendmap has to be combined with Microsoft Excel to satisfy the requirements.

- Odoo

Odoo is a web-based management software package. It has a lot of different modules that can be combined. These consist of packages like sales, project, website maker, inventory and more. The software covers a broad spectrum of different business processes, but most packages are not extensive or feature rich. All packages are really surface level and there is also no package for the creation and management of material lists and building activity lists. Odoo offers however the possibility to customize or add extra features with Odoo Studio, which is a zero-code drag and drop development area. With Odoo Studio it would be possible to make Odoo a suitable program, however it would still be impossible to create an extensive enough material list management tool. For this another program has to be used. Therefore, Odoo has to be combined with Microsoft Excel to satisfy the requirements.

- Exact

Exact is a cloud business software solution for small and medium sized businesses. It is a complete feature rich purchase and sell management system. It has a lot of features for creating invoices, receipts and packing slips. However just like SpendMap it lacks the possibility to create and manage material lists and building activity lists.

- Bizagi Studio

I looked at the program Bizagi Studio, which is just like Mendix a business process automation development platform. Compared to Mendix is Bizagi Studio an older platform. Bizagi Studio uses a three-stage development cycle. Starting with firstly modeling the complete business process according to the BPMN modeling method. Secondly building the process apps, which is done with a drag and drop system. Lastly by running the application.

- Microsoft dynamics 365

Dynamics 365 is a cloud-based ERP and CRM enterprise system. Dynamics 365 also offers a range of different business applications and features, with again some great logistics tracking features. It is a more fixed application and only offers some small customizability options.

6.3 Solution selection

I used a rating system to select the optimal solution out the defined solutions from 6.2. This rating system was setup according to the multi-criteria decision analysis (MCDA) (Great Britain. Department for Communities and Local Government, 2009, pp. 46–72). MCDA provides an overall ordering of options, from the most preferred to the least preferred option. The specific MCDA method has been selected in a literature review, which can be found in chapter 4.4. A more theoretical look at the method can also be found in chapter 4.4. The MCDA method that I will be using is AHP + TOPSIS. The importance and impact of a criteria is considered by giving a weight to every assessment category. Measuring the extent to which options achieve objectives is done by giving a score to each criterion. How higher the score of a criterion, the more suitable the platform is. With the score and weight of every criteria a weighted score can be calculated by multiplying both the values with each other. I created six sections that all cover a different aspect of the requirements. All these sections and criteria are set up according to the requirements of section 5.2 and where discussed in detail with my supervisor at BPE. The solutions are scored with a score between one and five. A One means that the platform completely lacks the feature, the criteria is not available for the platform or the platform is compared to the other platforms a worse option. A two means that the platform has the possibility to achieve a feature with the use of another platform, the criteria is not available for the platform but there are other options out there or the platform is compared to the other platforms worse than the median. A three means that the platform possesses the feature, but not in a completely sufficient way. The criteria are available for the platform in a basic form or the platform performs average compared to the other platforms. A four means that the platform possesses the feature in a sufficient way, the criteria for the platform is available or the platform performs better than the median. A five means that the platform possesses the feature completely with no single shortcoming, the criteria for the platform is complete and always available or the platform performs excellent compared to the other platforms. By selecting the weights and scoring the solutions against the criteria, final scores can be calculated. All the specific calculations and scores of the different solutions can be found in Appendix B: AHP + TOPSIS calculations. The final ratings of all platforms according to the MCDA can be found below in table 5.

Total											
Category	Weight	ERP PDC	Excel + SQL	Mendix	Zoho	Full development	Spendmap	Odoo	Exact	Bizagi Studio	Microsoft dynamics 365
Support	13,71%	0,583	0,343	0,411	0,480	0,308	0,514	0,480	0,480	0,411	0,514
Future proof	13,71%	0,411	0,384	0,411	0,411	0,425	0,329	0,411	0,411	0,411	0,466
Costs	7,83%	0,179	0,313	0,257	0,257	0,313	0,324	0,213	0,157	0,190	0,224
Feasability	13,71%	0,651	0,446	0,343	0,343	0,274	0,686	0,411	0,548	0,308	0,514
Security	4,99%	0,183	0,183	0,233	0,200	0,233	0,183	0,183	0,183	0,200	0,200
Features	46,05%	1,641	2,137	1,868	2,000	2,163	1,465	1,820	1,712	1,868	1,664
Total	100,00%	3,648	3,806	3,523	3,691	3,717	3,501	3,518	3,491	3,389	3,582

Table 5: MCDA rating of all solution options

The five sections consist of support, future proof, costs, security and features, as can be seen in table 5. The first section, support, indicates how well every option can get aid when problems occur. I have given an average weight to this section because it is important that the platform can always be used and that problems don't obstruct the progress of the

workflow. The second section, future proof, indicates how often the platform gets updated, but also assesses how suitable the platform will be in the future. I have given an average weight to this section because it is also one of the more important categories. If the program is not future proof, it would eventually be outdated and not be efficient enough anymore or even may be unusable. The third section, costs, indicates how expensive the purchase but also the operating costs are of the platform. I have given a lower than average weight to this section because it is important that the costs of the platform are not exponentially higher than the benefits it delivers, however it is more important that the platforms functions properly and efficiently. The fourth section, security, indicates how well the platform is secured against vulnerabilities. This is only estimated on a global level and not in detail since that would be out of the scope of this project and would not be possible due to time limitations. The importance of this is also not that high and because of this I have given a low weight, However I still included it in the evaluation since the platform should be safe to use and data leaks should be prevented. The fifth and last section, features, indicates how well all the features that were set up in the requirements list are available in the solution or if there are possibilities to create an environment wherein those requirements would be satisfied. I have given the highest weight to this category since this category indicates how feature rich the application is and if all requirements can be met.

Now I will go more in depth into every criterion. The first criterion of the support section is the help/assistance user issues. This criterion gives a score assessed by the level of support that is included with the platform, how easily available this support is and/or how fast the support is available. The ERP platforms such as Plan-de-CAMpagne, Zoho, Spendmap, etc. all score very well for this criterion because they offer support for their complete system. Mendix and Bizagi Studio score a little lower because they are development platforms. They offer complete support, but because the system will be unique it will be more difficult to find appropriate solutions. Lastly will pure development platforms such as Microsoft Excel and frameworks score the lowest because there is no support available. However, there is a lot of help available online to solve all kinds of problems that occur in these platforms. The second criterion of the support section is help/assistance technical problems. This criterion gives a score assessed by the level of reliability of the servers that is promised by the platform and by the level of technical support that is offered by the platform. All platforms score well for this platform, because all platforms offer at least an uptime of 99 percent. All platforms also offer a support system for when server problems occur. Small scoring differences are made because of if there is in person support possible and if the database system will be complex and therefore more difficult to get sufficient support. The third criterion of the support section is costs of assistance. This criterion gives a score assessed by how expensive it is to get user and technical support. None of the platforms had the possibility to get free in person support, it was only possible to get free support through a phone call or email. The development platforms only had the possibility to get free support by consulting forums and other online sources. It was possible to get in person support for a payment, but this was just as expensive as hiring a developer most of the times. The fourth criterion of the support section is early adoption errors. This criterion indicates the chance that software problems in the platform occur during the implementation and adaptation of

the platform. This also indicates how high the chance is of requiring user support and/or technical support. This is most likely the case by platforms that are developed by me and/or BPE itself, because that would be brand new software without long testing and improving durations. How higher the score for the criteria is, how less likely it is that early adoption problems occur. All criteria have the same weight because they all have a significant effect on the occurrence of errors or on how efficiently errors can be fixed.

The first criterion of the future proof section is the automatic updates. This criterion gives a score assessed by how often the platform gets updated by the creator/developer of the platform. This are automatic updates that don't need extra development by BPE itself. If these updates have extra cost associated than that is also taken into account with the scoring of this criterion. The development platforms score the lowest for this criterion because they almost never get updates to their platform that can directly be implemented without any modification to the code. The second criterion of the future proof section is the expansion possibility. This criterion gives a score assessed by the possibilities of expansion or adding extra features within the platform. It is not only about how many extra features can be created and/or added it is also about how suitable these features will be for BPE. The development platforms score the highest for this criterion because they offer the most freedom to create an extra feature. The third criterion of the future proof section is the dependency on. This criterion gives a score assessed by how dependent BPE will be on the creator/developer of the platform and how high the potential is of this causing problems. This depends for example on how high the change is of the creator/developer of the platform going out of business and/or the creator/developer of the platform stopping the platform from operating. The fourth criterion of the future proof section is the upcoming innovations. This criterion gives a score assessed by if there are useful features that will be released/added in the near future to the platform. All criteria except the dependency on criteria have the same weight. I have done this because all those criteria have a significant impact on how future proof a platform is. Only the dependency on criteria was given a lower weight because all platforms that come from the requirements already provide a stable and widely used platform, so the impact of this criteria is significantly lower.

The first criterion of the costs section is one-off costs. This criterion gives a score assessed by how much the one-off costs are of the platform. Most platforms score high for this criterion because they have mostly no upfront costs for using them. Plan-de-CAMPagne and Bizagi Studio are the only platforms with a significant upfront cost. The second criterion of the costs section is monthly costs. This criterion gives a score assessed by how much the monthly costs are for using the platform. This criterion takes into account monthly license costs, support costs and server costs. The third criterion of the costs section is future costs. This criterion gives a score assessed by how much the future costs would be if the capacity or features would be expended. This criterion scores the options on costs associated with this and if it is even possible. I have given the criterion monthly costs a much higher weight because this is the most impactful cost as it is a returning cost. The one-off costs only have an impact when buying the platform, but it has little impact in the long run. The monthly costs will most of the times quickly total up to a higher total cost than the one-off costs. The

future costs also only has an impact when growing the business. So, I have given the one-off costs and the future costs both a lower weight because they both only have a small impact on the total costs. The one-off costs only when purchasing the business and the future costs only when growing the business.

The first criterion of the feasibility section is time consumption. This criterion scores the option on how fast the platform could be operational for BPE. This considers potential development time and set up time. The development platforms score significantly worst for this criterion since they have a lot of development time associated with them compared to the already made solutions. The second criterion is problem potential. This criterion estimates how high the potential would be of a problem occurring when setting up or developing the platform. How larger the task of setting up and/or developing the platform most likely the higher the change of unforeseen problems occurring. Therefore, development platforms score mostly lower than the already developed platforms. The third criterion of the feasibility section is programmer skills with the platform. This criterion relates to the level of experience that I have with the platform and the tasks associated with creating a working artifact with it. All three of these criteria are important since they all have a significant impact on if it is possible to create a working artifact. I have chosen to give problem potential a slightly higher weight than the other weights. This is the case because encountering large problems could halt the creation of the artifact completely and result in no solution for the current problems, instead of a longer development time but with still a working end result in prospect.

The first criterion of the security section is server security. This criterion looks at how high the server up times are of every platform. This is for all platforms as earlier mentioned at least an uptime of 99 percent. Since there are no real on paper differences I have given them all a similar score. The second criterion is platform security. This criterion scores on all the types of security measures that are in place to protect the data from leaking out. This goes from password security to how the database is stored. The third criterion is user security. This concerns how well different users can have different permissions, but also how good the security of a certain user is. This is less on platform vulnerabilities and more focused on user specific vulnerabilities. All platforms had the possibility to develop a user system or had already an integrated feature like that. All three of these criteria have been given the same weight since they all have a significant impact on the security of the overall platform.

For the last section features are almost all criteria related to the established requirements. I looked at how well these requirements could be accomplished by the specific platform. The weights that were given to these criteria were established by how impactful the feature would be and how often it would be used in the workflow of the company. The only criteria that are not part of this are the ease of use and learning curve criteria. The ease of use criterion is an estimation of how user-friendly the interface is and how well every feature can be accessed. The learning curve criterion is an estimation of how easy it would be for the company to learn to work with the platform. It would help if the platform performs certain tasks in similar ways as the old platform so no new skills have to be learned. I have given the

learning curve a higher weight since the ease of use would always have an impact on the performance of the platform, while the learning curve only has an impact on the initial adoption of the platform.

Out of table 5 can be seen that Microsoft Excel in combination with SQL came out as the most appropriate option. This was the case because it scored well for the costs and features sections, since it is one of the cheaper solutions in which all required features can be programmed with the build in programming language VBA. Still one of the biggest negatives of this solution is that it is not a ready-made solution and that a lot of features must be programmed. However, a lot of the ready-made solutions didn't provide the necessary features that were established. With this conclusion is my fifth knowledge question answered, *"Which is the most effective and appropriate solution for the company?"* The answer is Microsoft Excel in combination with SQL.

7 Design of artifact

In this chapter, I will give an overview of how with the chosen solution from chapter 6 a design was made and how it was mapped to fit into the company's workflow. This design was setup according to the methodology discussed in chapter 3. Throughout this chapter will also my last knowledge question, *"How can the chosen solution be integrated into the current workflow?"*, be answered with the objectives and designs given.

7.1 Objectives

For the creation of the artifact I set up some objectives for the creation of the artifact. These objectives give a clear view of all features that should be present within the final creation. The objectives should also make it easier to plan the steps that need to be taken to achieve a desired result. The scale and number of objectives are set up according to the limited time that is available. I have set up objectives that would deliver a so complete and feature rich artifact as possible. I have chosen to do this because then the end result would best give a clear representation of the effectiveness and further potential of this solution. In setting up the objectives I have used the requirements set up in chapter 5.2. A list of objectives can be found below.

- A possibility to manage and switch between different projects.
- A possibility to save and manage a database of materials, contacts and prices.
- A comprehensive material list in which a lot of properties can be added and financials can be recorded.
- A way to insert details from the database into the material list. This consists of ways to make adding materials to the material list as efficient as possible.
- A possibility to create different sections within the material list. Make it possible to distinguish different stages of the project.
- An overview page that gives insight within the overall financial status of a project.
- A way to create purchase orders, confirmation of orders, receipts and packing slips automatically.
- A way to track the logistical status of a material.

7.2 New workflow

To better get a view of how the artifact will ultimately function within the overall procurement and assemblage workflow of the company I have created a map of how the new workflow should look like. This new workflow will not be that different from the current workflow since it will fulfill the same tasks in almost the same way. Only some tasks will be automated and a database structure was added to also speed up the workflow events. The new workflow is set up according to the current workflow that is mapped in section 3.3 and the objectives that are setup up in section 7.1. The new workflow can be found below in figure 9. The complete workflow with all the subprocesses can be found in appendix C: New workflow models.

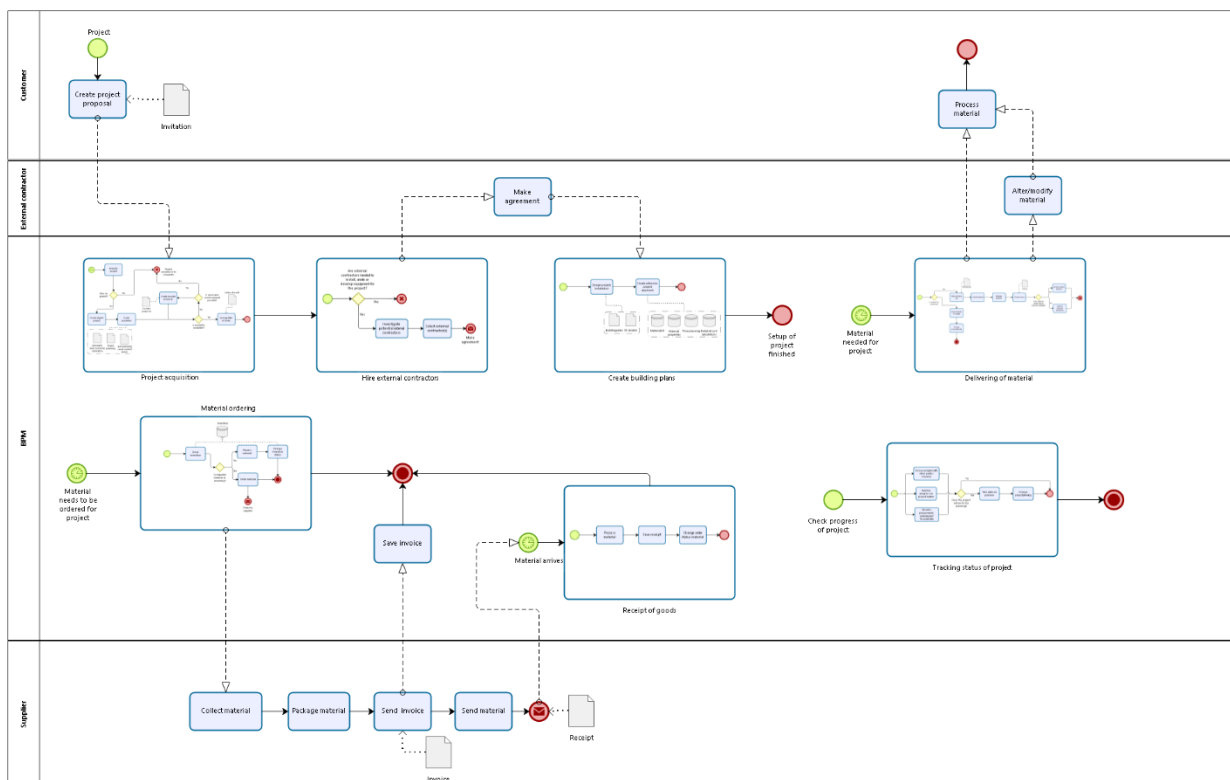


Figure 9: New workflow of the company

The changes to the workflow are very minimal, since the activities done are still almost the same. The only differences are that the system now directly uses a database system to save everything and that some activities are now automated, such as changing the order status of materials, processing cost calculations and the creation of order papers.

I have also created a new software structure to give insight in how all the software applications should correspond to the new workflow. This software structure model can be found below in figure 10.

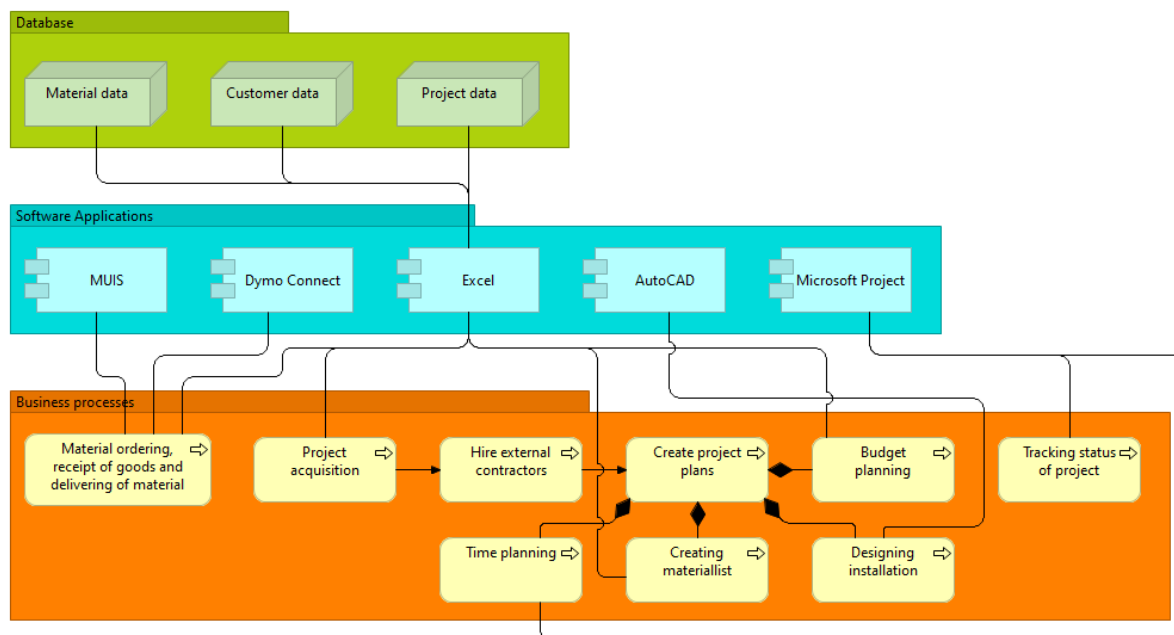


Figure 10: New software structure of the company

The differences with the old software structure is that now all project planning related activities are done with Excel instead of a combination of Excel and the ERP system. Now is also the database layer connected to Excel instead of the ERP system.

7.3 Database design

For the database I decided on using a structured query language (SQL) based database. SQL itself is the programming language used to communicate with the database. The database is effective in handling structured data where there are relations between different variables of data. I have chosen for SQL because it is effective in storing structured data, which is the case for my artifact in storing materials, contacts and projects. It is also the industry standard and most used database structure. I set up the SQL database with MySQL. MySQL is a opensource management system for databases such as a SQL database. I have chosen for MySQL because the community version is free, it is one of the most complete and feature rich options and I have already prior knowledge with the platform.

Before setting up the database I created a design which corresponds with the objectives set in section 7.1. This can be found below in figure 8. For this figure I have used the Entity-relationship model (ERD) notation (Song, Evans & Park, 1995). This is a widely used database modeling notation that gives a clear indication of how the database functions.

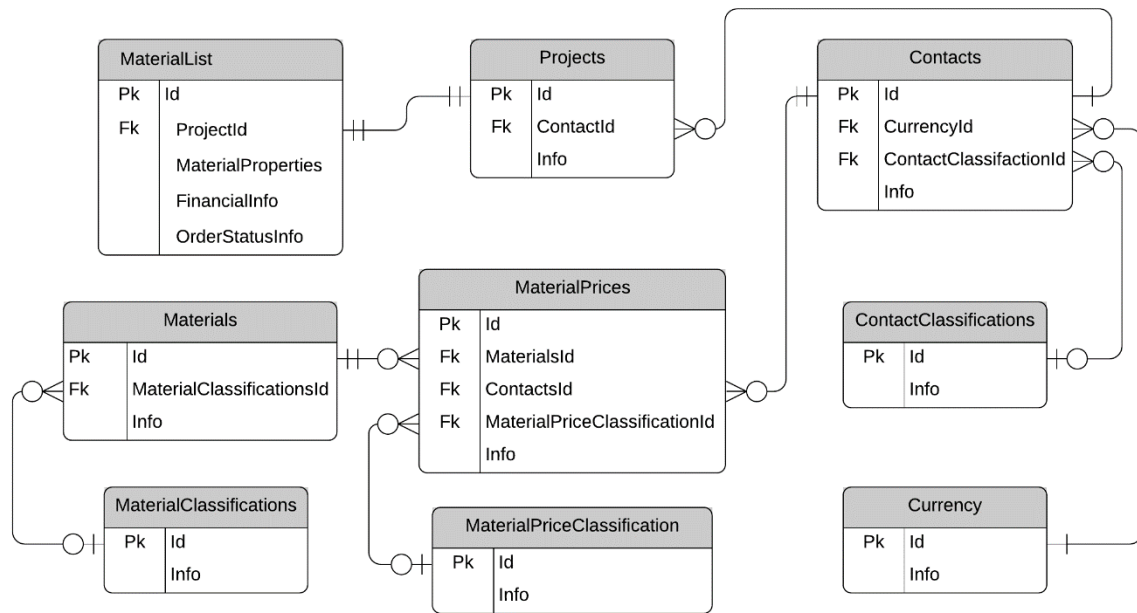


Figure 11: Database structure design

In figure 11 can be found that there are 9 tables. The table material classifications saves information about the entered material classifications, this info is then used by the material table to link these classifications to a material. The material table saves info about a material and the linked classification to that material. The same principle applies for the contacts, contact classifications and currency tables. Info about the contact classifications and currencies is entered and then linked to a contact in the contact table. So, the contact table saves all contacts with a reference to the entered classification and currency. The same also applies to the material price and material price cost classification, only the material price table also uses references to the materials and contacts tables. In this way can the material price table save a price at a supplier for a certain material. The project table saves info about the projects and uses a reference to the contacts table to save all info about the project owner/customer. Lastly is the material list table used to save all info about the material list. It uses a reference to the project table to know to which project a materialist is linked. The material list is however not linked to the materials or material prices table because by separating them small one-off changes can be integrated in the material list without needing to change a materials property. The location of every detail of the material list also needs to be saved to the material list table. In this way it is possible to interchange material lists and rebuild them the exact way as how they were created.

7.4 Interface design

To get a better view of how the artifact will function and look I started by designing a layout for how every part and function would link together in the artifact. The goals of this design were to make every function clearly and easily accessible, include all objectives that were set up in section 7.1 and to include all database needs as set up in section 7.3. The result of this design can be found below in figure 12.

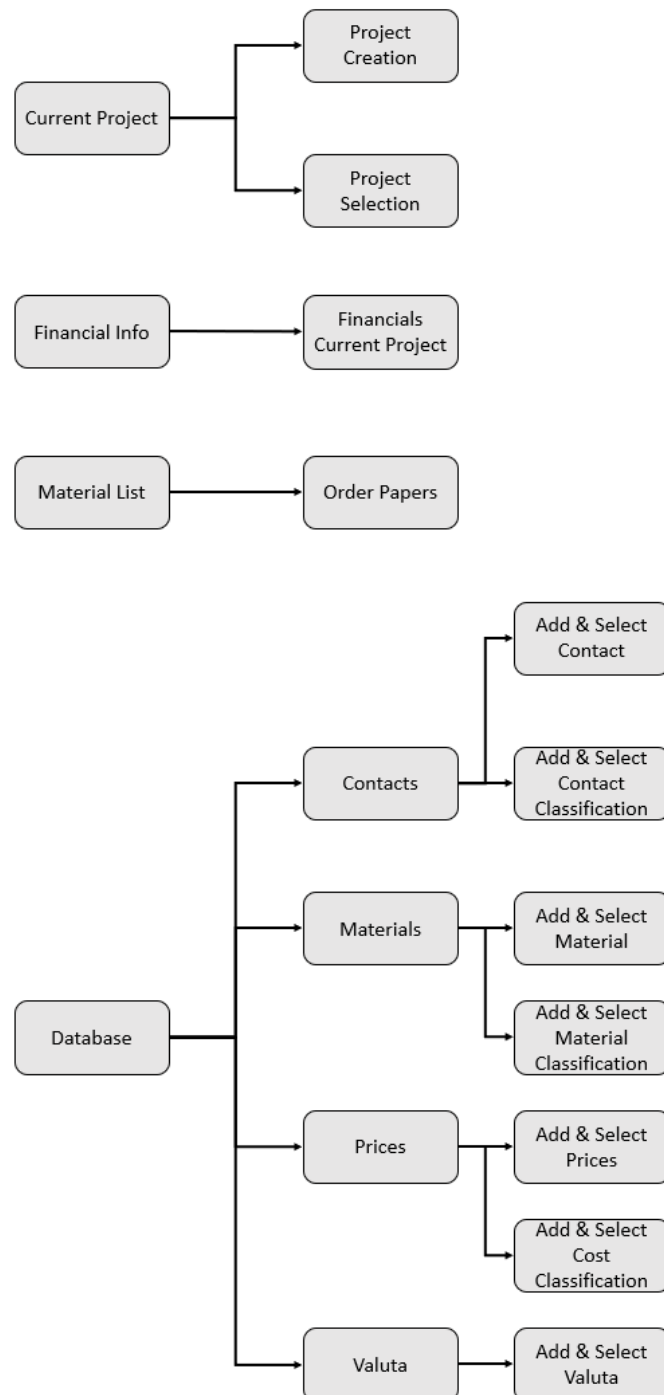


Figure 12: Artifact layout design

With this artifact layout design I selected which parts should be best suited for the interface of the artifact. This is selected to make all activities quickly accessible and to have the most

significant info and activities on the interface. With these functions I created a design for the interface. This interface design can be found below in figure 13.

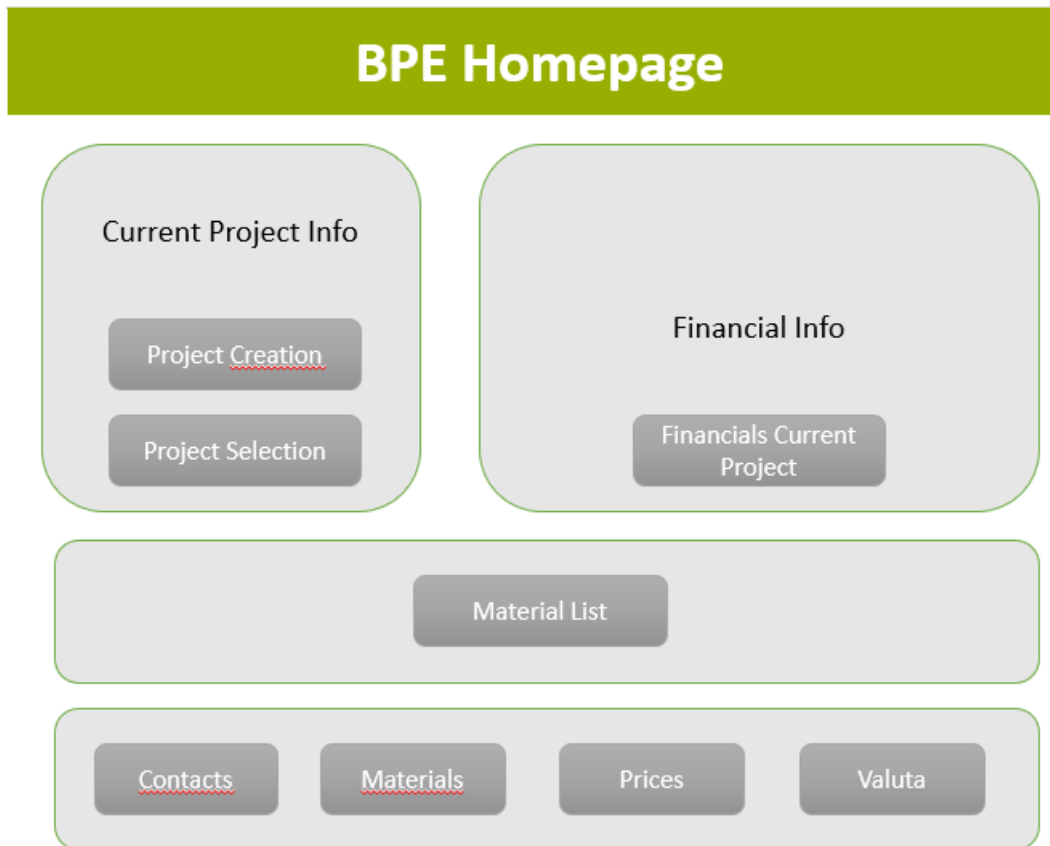


Figure 13: Artifact interface design

In the artifact interface design you can see that I have divided the interface into four different sections. I have done this to keep a clean and organized overview for the user. In the left upper corner are options to select the current project that the user is working on and get some information about this selected project. In the right upper corner can the user see summarized info about the financials of the project to get a quick indicator on how the project is doing. You can also open up a more elaborated financial overview on a new page from there. Below these two sections is a section with a button that opens the material list. In the future can more features be added to this section such as an inventory system. The last section at the bottom holds links to all database activities.

8 Artifact functionality

In this chapter, I will explain the functionality and features of the artifact that I have built. I will also show that all objectives set up in chapter 7.1 have been satisfied. For an extensive user instruction manual on how to control the artifact have a look at appendix D: User instruction manual for the artifact.

8.1 Interface

The interface of the artifact serves as gateway to every other functionality of the artifact and to give some quick summarized information to give a quick status update about the current progress of a project. All different functionalities are linked with buttons, these buttons are just a link to another worksheet or an userform. Depending on the worksheet, different actions happen when they get initialized, but this is explained in the concerned functionality below. The summarized information in the interface gets updated when this is altered. This is almost always done by indirectly loading data out of the SQL database. The final look of the interface can be found below in figure 14.

The interface is titled "BPE Boelsma Projectmanagement & Engineering B.V.". It features a green header bar. The main content area is divided into four sections:

- Project Selection:** Contains fields for Project Nr., Customer, Project Description, Status, Project Nr. Customer, Revenue, and Hours BPE, each with a green button. A large green button labeled "Project Selection" is at the bottom.
- Status:** Contains a field for Open Projects with a green button. To the right are buttons for "Backdoor Toggle", "Database Login", and "Financials Selected Project".
- Navigation:** Contains a single green button labeled "Material List".
- Navigation Database:** Contains four green buttons labeled "Contacts", "Materials", "Prices", and "Valuta".

Figure 14: Interface

8.2 Database structure

The database gives a location for all project info to be stored. This is an SQL database as explained before in the chapter 7. This database is used to store customer and project related data but also placement data to make it possible to order data. An example of where this placement data plays a big role is in the material list. To make it possible to rebuild the material list in the different sections and subsections as the user ordered it himself, the

exact row location of every entry and header location is stored. This makes it possible to completely recreate the material list for every project automatically.

Most categorical and non-project specific data can be directly added, modified and deleted from the interface with the use of userforms. These types of data are valuta data, materials and their specifications, prices for the materials and contacts (such as project employers and suppliers). More information about this can be found in section 8.4. The other types of data that are stored in the database are the project information and the related material list. The project information can also be accessed from the interface; however the material list consists of it's completely separate page. Furthermore, does the user not have to edit the database directly, since the artifact can be used as interface to access and edit the database in any way applicable.

8.3 Project selection

Projects can be selected, added, modified and deleted from the selection menu that can be opened from the interface. Details like customer details, applicant details, project locations, project type, project status and more can be saved within the database for every project. Different statuses can be given to a project to indicate in which state of execution the project is. The different stages are: prospect (to save info about potential projects), open (to indicate that a project is active), closed (to indicate that a project has finished), on hold (to indicate that an project is currently halted) and failed (to indicate that a potential project didn't go through or if a project was cancelled). Every project that is created also has a new material list linked to it. This material list gets automatically created when the connected project is selected. So, with this feature I have satisfied the first objective (= A possibility to manage and switch between different projects).

8.4 Adding data to the database

As described in section 8.2 and 8.3 all data except the material list can be added to the database directly from the interface page. For adding data, a fill-in form is loaded for the specific type of data. All data that is important and currently known by the user can be entered in this fill-in form. Fill-in areas are indicated with yellow in the fill-in forms. This makes it possible when the user clicks the save button to automatically add the data out of the fill-in form to the corresponding database entry. For deleting data, a selection menu is loaded with all current records. In this selection menu an entry can be selected and this entry can then easily deleted out of the records and database with a deletion button. For the modification the user can also select an entry out of the previously mentioned selection menu and then pressing the modify button. This loads all data out of the selected entry into the fill-in form. In this fill-in form can the user then make edits. After that can the user save the modifications with the same save button. The system automatically overrides the selected entry with the newly entered information. Lastly is the user also able to view all saved entries for a specific type of data. From this view is the user also able to add a new entry or delete and modify a certain entry. Furthermore, is the complete material list saved in its own page. This is just an overall save button that overrides the complete currently

saved material list with the complete new material list. The material list cannot be altered in another way or be deleted. So, with this feature I have satisfied the second objective (= A possibility to save and manage a database of materials, contacts and prices).

8.5 Material list

The material list consists out of an overarching header control area and input fields with corresponding section controls integrated. The overarching header control area gives the user functions that influence or use the overall material list. The options that are integrated within this overarching header control area are: autofill missing elements in the input fields, saving the material list and creating order papers.

The input fields are used to create a list of materials that is needed for the project. Subsequently, suppliers, prices, budgets and order papers can be linked to these materials. This creates a list with all material data of the complete project.

In the material list input fields can be put into different sections and subsections. This makes it possible to order materials and distinguish different sections of a project easily. Overall provides the material list an area to manage the supply of all materials for the project. So, with this feature I have satisfied the third objective (= A comprehensive material list in which a lot of properties can be added and financials can be recorded), the fourth objective (= A way to insert details from the database into the material list. This consists of ways to make adding materials to the material list as efficient as possible), the fifth objective (= A possibility to create different sections within the material list. Make it possible to distinguish different stages of the project) and the eight objective (= A way to track the logistical status of a material).

8.6 Order papers

Within the material list can order papers be created. The order papers that can be created are: Purchase order, confirmation of order, receipt and packing slip. These order papers can be used for ordering and sending materials from and to contacts. The order papers are created by giving all concerned order papers the same number and then by selecting the appropriate order paper. Now the order paper will be automatically created for the user. This order paper can then still be modified by the user by just editing the Excel fields or by selecting different options in the dropdown boxes. These dropdown boxes hold contact info related to the materials and the order paper will automatically be altered when a different contact is chosen out of a dropdown box. If the order paper satisfies the user's needs it can be saved with a button to any folder on the pc as a pdf file.

When an order paper is used the user can press a confirmation button which makes the concerned fields in the material list green, to indicate at which part of the ordering process a material is. So, with this feature I have satisfied the seventh objective (= A way to create purchase orders, confirmation of orders, receipts and packing slips automatically).

8.7 Financials

The material list serves also for inputting all different costs and profits for all materials of the project. A lot of costs are automatically calculated from the price of the materials, but discounts and changes of prices can still be added by the user.

Next to the input of all prices in the material list is there also a financial overview page. This page can be accessed from the interface. This overview lists the budget calculation, total purchase price, invoice already received, incoming invoice, total realized costs, deviation from budget, meerwerk and a total sum up of all costs. These prices are all automatically taken from the material list for every different subsection. This gives an insight in the overall financial standings of the project, but also gives insight in which areas of the project where most and least profitable. So, with this feature I have satisfied the sixth objective (= An overview page that gives insight within the overall financial status of a project).

9 Artifact validation & evaluation

In this chapter I will discuss how well the created artifact performed and the acceptance of the artifact by the company according to the technology acceptance model.

The technology acceptance model, hereinafter referred to as TAM, is a model that was created to assess how well an information system gets accepted by the users (Davis, 1989) (Davis, Bagozzi, & Warshaw, 1989). I have chosen for this model because of multiple reasons. Firstly, it is one of the most widely used models. Secondly, it is a great way to assess how well an information system functions but also test if it is usable for the end user. Lastly, it is a quick validation method that doesn't exceed the time limitations of this project. Other more elaborated models almost always consist of a more comprehensive test period of multiple months (Lai, 2017).

To test the artifact with the TAM I have created an assessment form tailored to test the perceived ease of use, perceived usefulness and attitude toward using the system. This form was then filled in by my supervisor in the company, followed by a quick discussion about his findings. The filled in form can be found in appendix E: Technology Acceptance Questionnaire. The assessment form was only filled in by my supervisor in the company because he is the only one in the company that would be working with the artifact since the company is small and has no other staff members that do the same tasks.

The supervisor was satisfied about the ease of use and clarity of the system. This was also the intention by creating the application in Excel with which the company already have worked for multiple years. This implies that my implementations remained close to the original structure and that it therefore is still easy to use for the company. Furthermore, was the supervisor especially pleased with the features that were implemented to speed up the work processes. I have worked on multiple ways of speeding up the current workflow by for example implementing automatically created order papers, simple building options for the materialist and automated material information appending within the materialist. The supervisor was satisfied by the workflow improvement, but was not yet completely convinced that this could lead to the possibility to take on multiple more projects, since there are still a lot of other steps outside of the scope of the artifact that would have to be done within a project. Lastly, was the supervisor content with the result and would he like the continuation of development of such a platform.

10 Conclusion

This is the last chapter of the thesis. In this chapter I will give the conclusions to my research and give recommendations and future plans for the company to potentially continue the development of the artifact.

10.1 Outcome

The problem of BPE was that their current procurement and assemblage workflow was not efficient enough and too labor intensive. Because of this BPE ran into capacity problems and felt that improving the digital workflow of the company would be the most effective way to tackle these problems. Here the research reached the first knowledge question:

What workflow modeling language to use for the companies procurement and assemblage workflow?

After a literature research, which can be found in chapter 4.2, into the topic I landed on the BPMN workflow modeling notation because it is widely recognized, complete and I had worked with it before. With this notation could the workflow be analyzed and this lead to the second knowledge question:

What bottlenecks are there in the current procurement and assemblage workflow of the company?

This lead to five bottlenecks: IMuis has no communication with the rest of the workflow, AutoCad and Excel/ERP don't communicate, Excel and the ERP system lack the depth or small features the other possesses, Excel has no database functionality and Excel and the ERP system don't communicate. After analyzing these bottlenecks I could answer the third knowledge question:

Which is the most impactful bottleneck that can be tackled?

The answer to that knowledge question is: The workflow activities in Excel and the ERP system are not integrated with each other. This is a combination of the bottlenecks described above that could be tackled at once. Trying to solve this bottleneck lead to the fourth knowledge question:

Which solutions are there to solve the chosen bottleneck?

This lead to a list of 10 different solutions that came out of a literature research, an open interview with my supervisor and open interviews with two competitors. A grading method had to be chosen to select the best solution out of the 10. This lead to the fifth knowledge question:

What is an appropriate grading scheme for selecting an effective and appropriate solution for the company?

Out of a literature research, which can be found in chapter 4.3, came that the most appropriate grading scheme was AHP + TOPSIS which is a multi-criteria decision analysis method. This method was used to answer the sixth knowledge question:

Which is the most effective and appropriate solution for the company?

I found that the most appropriate solution was to develop a well fitted software solution in Excel with the use of a SQL database. In this way I could imitate the current workflow by using the same platform as the one the company already uses and build an artifact that would be able to fulfill all set up requirements. The development lead to the final knowledge question:

How can the chosen solution be integrated into the current workflow?

Designs for the workflow integration, software structure integration, database design and interface design can be found in chapter 7. After answering all knowledge questions it leads us back to the action problem:

Innovate the current procurement and assemblage workflow and make the operations thereby more efficient and less human labor intensive.

I have created the software artifact according to the objectives and design that were set. An more elaborated description of its functionality can be found in chapter 8. Ultimately, I think that I have created an artifact that shows the potential to solve the bottlenecks stated in this research and the action problem, but that still some more work is needed in bug fixing and finishing up extra features. What specific shortcomings there are will be further discussed in section 10.3. The origin of these shortcomings is that during the development of this platform I found out that building such a program was more work than first expected. This was the case because a lot of unforeseen errors would come up and a lot more work was often required to integrate some features within the complete application. After development of the platform for a couple of months I had however delivered an application that had implemented all major goals and created a minimal viable product. Not all requirements are currently implemented, since that would be impossible due to time constraints. However, the basics are laid down for the application and a clear indication of how well this application could improve the current workflow can be established.

10.2 Recommendations

After delivering the artifact to the company there is still a lot of work required to achieve a finished product to achieve an artifact that would fulfill all set up requirements. Currently are the basics laid down, but more development would be required to finish up the improvement of the software structure of the company. All functional requirements that still will need to be finished will be discussed later in this chapter, but now I will first discuss my recommendations for the company to undertake to accomplish the completion for this artifact. Below you can find a list of recommendations for the company.

- I advise the company to look more into the artifact that I have created and try to use it in a real life scenario. Establish the potential improvements that the platform can bring.
- Look into all options that I have looked at and potential new platforms that have come up. Look into if this is still considered the best option with the most potential.
- If the company still thinks that my platform can potentially bring the desired result, I would advise to look into potential further development options. For the further development would be required some basic SQL database knowledge and more advanced Excel and VBA knowledge.

Following my recommendations would in my opinion lead to the best most desirable outcome in fixing the problem of not having an efficient workflow.

10.3 Plans for the future

Due to the large size task of an artifact development and the limited amount of time that was available, there are still a lot of extension possibilities for the artifact. I will discuss all features that could still be implemented and should deliver an improvement to the artifact. These future features came up during the development of the artifact and in the evaluation of the artifact by me and the company. Below you can find a list of features and explanations of all these potential features.

- An extensive budget planner. Currently only a budget for a complete project and for every single material can be added by the user. A more extensive budget planner wherein different sections of the project could have different overall budgets would make it easier and more approachable for the user to manage the budget for a project. Automatic budget estimations that are based on previous projects would also help give the user quick information about the budget of a project.
- Reset buttons for locally loaded data. Currently categorial data and some functionality data for the material list are loaded locally in the Excel artifact to speed up loading times. Reset buttons for this data could be implemented by loading this information out of the database, this would prevent difficult error fixes when problems occur with this data.
- A data formatter for the Dymo label printing could be added to the artifact. Tag numbers of project materials need to be printed on a label and stuck on the

materials, this is done with an Dymo printer. Currently data out of Excel needs to be formatted by the user, but this could also be done by Excel automatically. This would save the user time when printing these labels.

- An inventory system could be added to the artifact. This could be implemented with the material list to make it directly visible which materials should be ordered and which materials are already in inventory for every project. This should speed up the inventory management for the company and should lower the amount of unnecessary material purchases for materials that were already in stock.
- An automatic project quotation creator could be added to the artifact. For every project a quotation is created, parts of these quotations could be automatically generated just as with the order papers to speed up this process.
- Split compositions of materials automatically in the material list. Currently compositions of materials can be added just like a single material, but there currently is no feature to see which materials make up a composition in the material list. Creating this feature would make compositions significantly more insightful and easier to understand.
- Valuta conversions could be added to the material list and financial overview. Currently only a single valuta could be used for a project because there is no way to convert them. Different valutas and their conversion rates can however already be added in the artifact, only a conversion feature still needs to be implemented.
- An option to overwrite material details straight from the material list could be added to the artifact. Currently it is only possible to alter material details from the modification menu in the interface. Also adding this feature to the material list would speed up this process in applicable occasions.
- Transport and other material costs currently don't have a separate input field from the complete material price. Separating these costs would give more data about how certain prices are build up and calculated.
- A planning of work activities and costs of these activities could be implemented into the artifact. Currently there is no feature in place to create a planning, budgets and record final prices of hiring people for the construction and management for the project. This would extend the functionality of the artifact significantly and should make it possible to completely manage all financial aspects of a project.
- Have proper worked out exceptions. If users operate the artifact incorrectly the system doesn't always respond with a proper and clear error message. A lot of these exceptions have been implemented but not yet for all cases.
- A way to set up the invoices. Have an more automated system to create invoices just as the order papers.

10.4 Contribution to literature

For the contribution to the scientific literature I hope that my research gives a clear view of an implementation of the design science research methodology (Peppers et al., 2007). Specifically on how to use it in a workflow improvement environment wherein bottlenecks are analyzed and tackled. I hope that my thesis also gives a clear indication of how to use the

methodology in combination with a multi solution selection procedure. Where multiple solutions are considered and that according to the multi-criteria decision analysis (Great Britain. Department for Communities and Local Government, 2009, pp. 46–72) a solution is chosen.

The artifact itself will not be publicly available, but ideas and designs can be taken from this thesis in designing a project planning artifact.

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Appendix A: Current workflow models

In this appendix all models of the current procurement and assemblage workflow can be found. This encompasses the complete current workflow and all its sub processes. In the figures below can all these models be found.

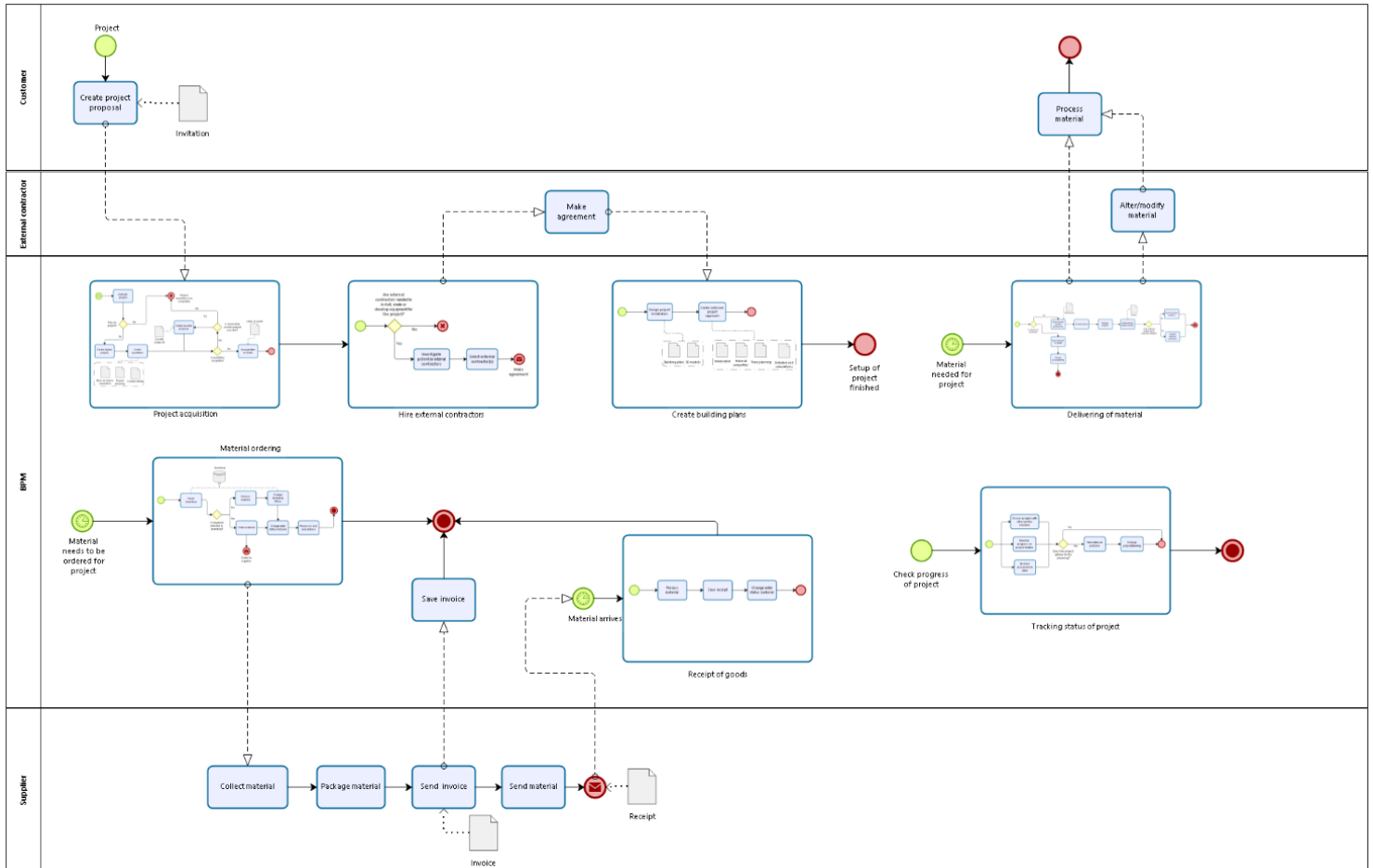


Figure 15: Complete current workflow

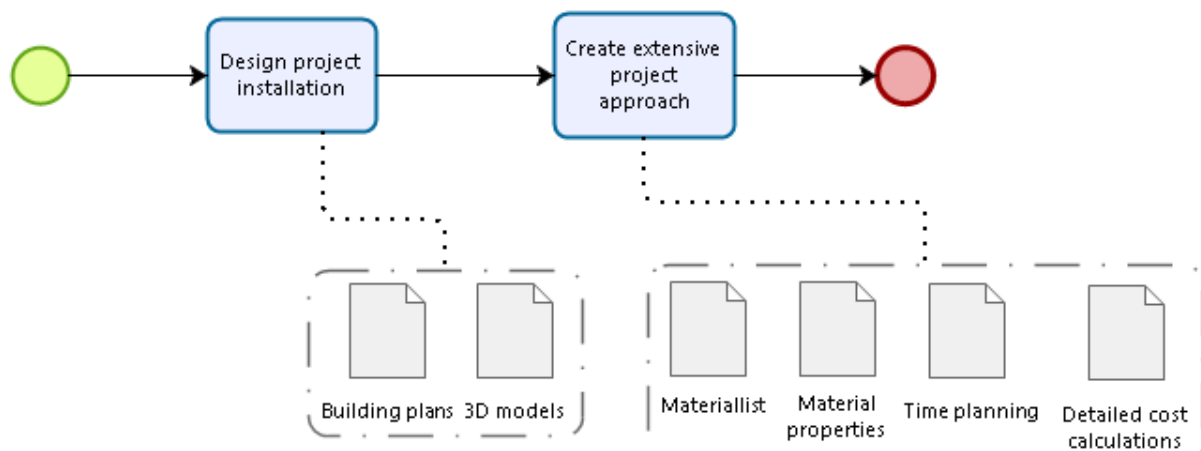


Figure 16: Project acquisition – Current model

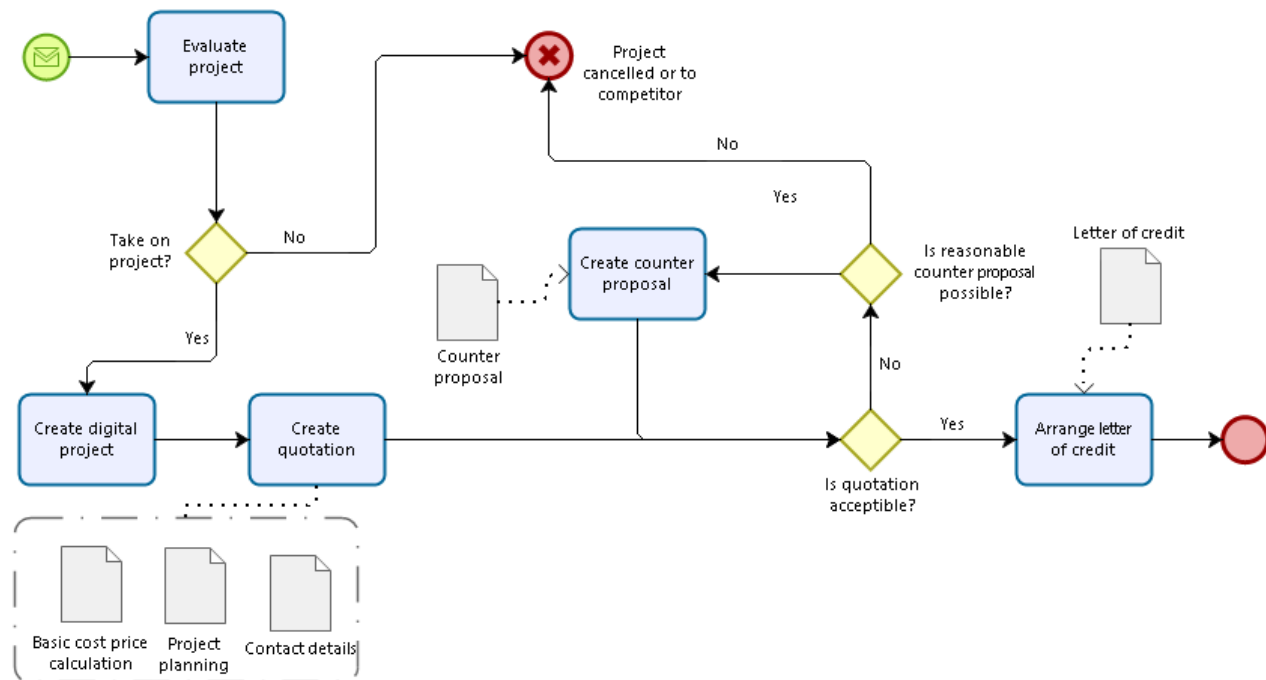


Figure 17: Create building plans – Current model

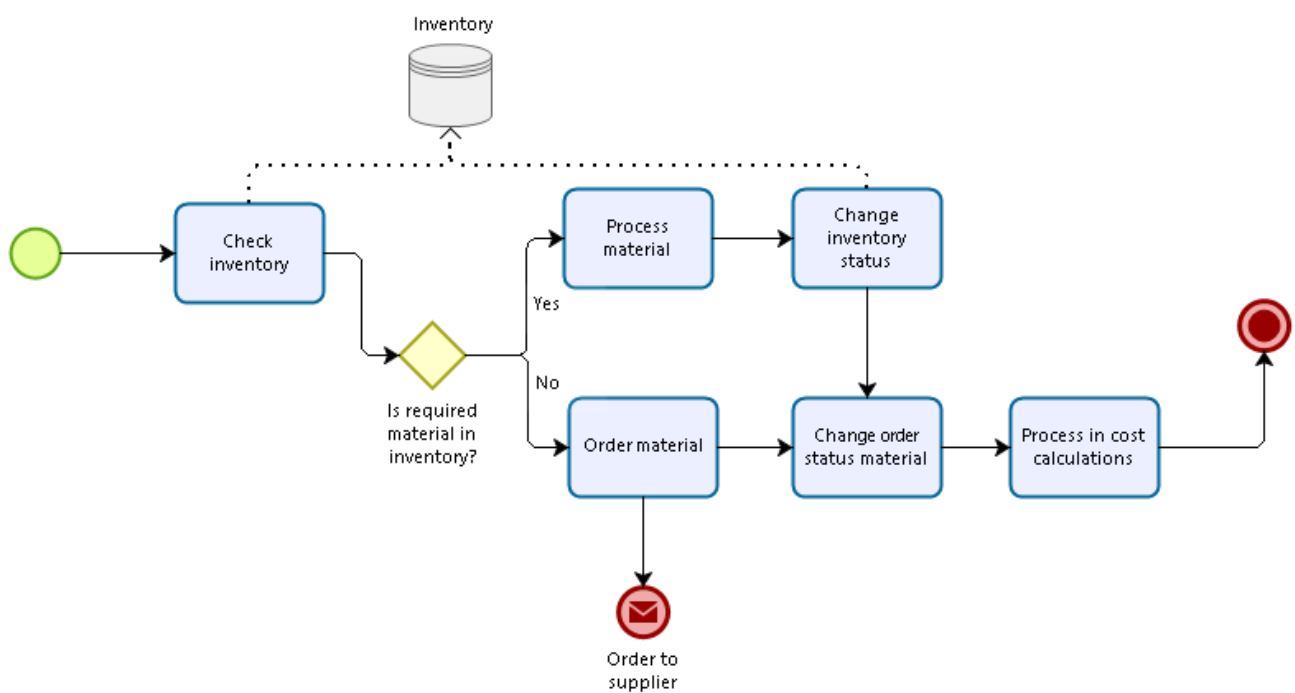


Figure 18: Material ordering – Current model

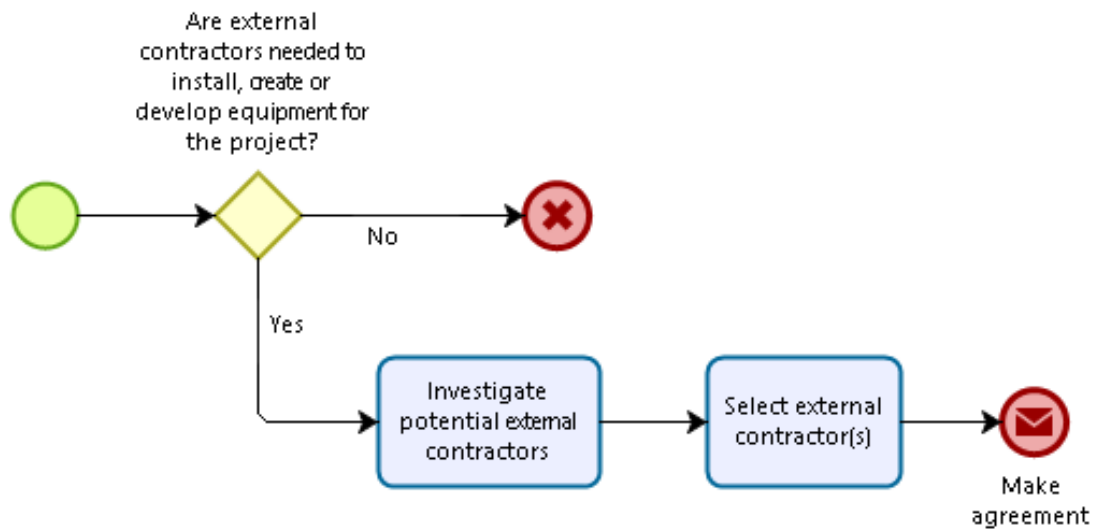


Figure 19: Hire external contractors – Current model

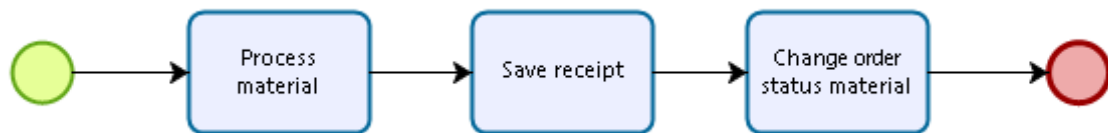


Figure 20: Receipt of goods – Current model

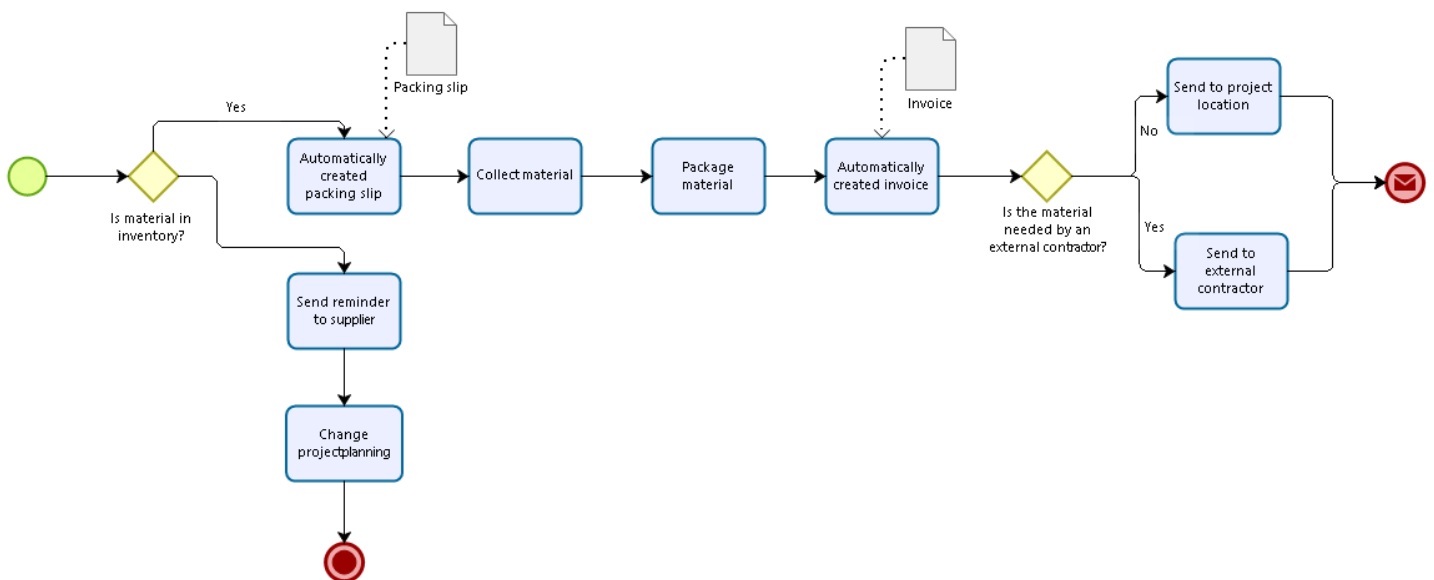


Figure 21: Delivering of material – Current model

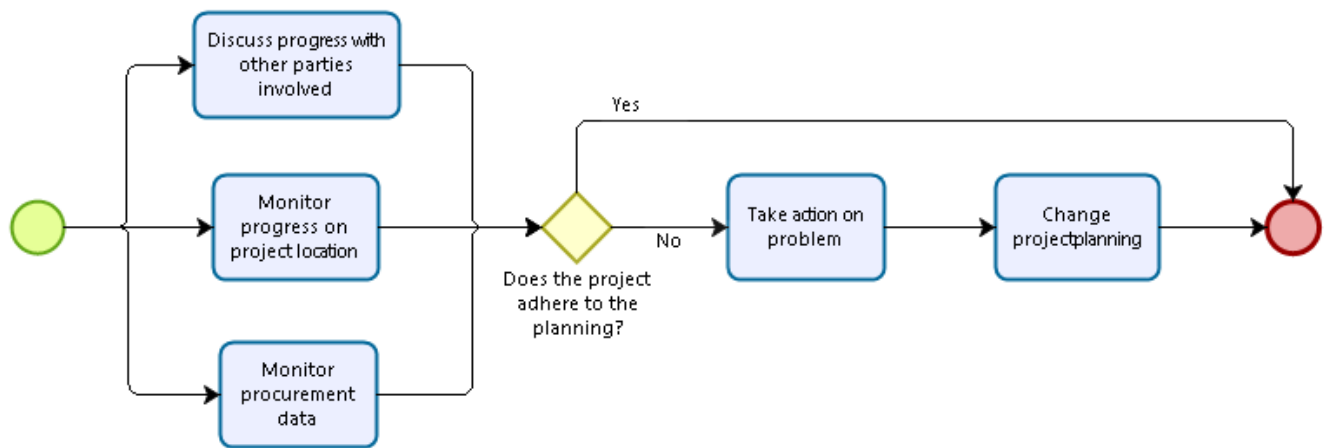


Figure 22: Tracking of project – Current model

Appendix B: AHP + TOPSIS calculations

In this appendix will all the AHP + TOPSIS matrixes be shown and how the weight percentages are calculated will be explained. Only the mathematical part will be covered, for a theoretical approach on this topic please have a look at chapter 4. For an explanation why certain weights or scores are given please have a look at chapter 6.

Appendix B.a Weight percentage calculations

To calculate the weight percentages or normalized principal eigenvectors four steps have to be executed.

- Fill in the AHP matrix with the nine-degree-scale, so give an assessment of how much more important a criteria is over another one. If a criteria is less important a fraction can be used. An example is illustrated in table 6 below.



Matrix		Example1	Example2	Example3
		1	2	3
Example1	1	1		
Example2	2		1	
Example3	3			1

		Example1	Example2	Example3
		1	2	3
Example1	1	1	1	2
Example2	2	1	1	2
Example3	3	1/2	1/2	1


Table 6: AHP calculation example 1

- The total of every column in the matrix is calculated. An example is illustrated in table 7 below.

Matrix		Example1	Example2	Example3
		1	2	3
Example1	1	1	1	2
Example2	2	1	1	2
Example3	3	1/2	1/2	1
Total		2,5	2,5	5

Table 7: AHP calculation example 2

- Divide tall entries in the matrix through the total number of that column. An example is illustrated in table 8 below. As can be seen in the first entry in the figure, $1 / 2.5 = 0.4$.



Matrix		Example1	Example2	Example3
		1	2	3
Example1	1	1	1	2
Example2	2	1	1	2
Example3	3	1/2	1/2	1
Total		2,5	2,5	5

		Example1	Example2	Example3
		1	2	3
Example1	1	0,4	0,4	0,4
Example2	2	0,4	0,4	0,4
Example3	3	0,2	0,2	0,2

Table 8: AHP calculation example 3

- Now can finally the weight percentages being calculated by taking the average of a row. An example is illustrated in table 9 below. As can be seen is now the weight percentage of Example1 0.4.

Matrix		Example1	Example2	Example3	Average
		1	2	3	
Example1	1	0,4	0,4	0,4	0,4
Example2	2	0,4	0,4	0,4	0,4
Example3	3	0,2	0,2	0,2	0,2

Table 9: AHP calculation example 4

Appendix B.b AHP + TOPSIS matrixes

In this section will all the different AHP + TOPSIS matrixes be shown. The relative weights are calculated according to the AHP technique as can be seen in the previous section (Appendix B.a). The weight calculations are split up into two different sections. There are six overarching categories that all have some more focused criteria within them. These six categories and the criteria within are separately analyzed with the AHP technique. All these weight percentage calculation matrixes can be seen in the tables below.

Matrix		Support	Future proof	Costs	Feasibility	Security	Features	normalized principal Eigenvector
		1	2	3	4	5	6	
Support	1	1	1	2	1	3	1/4	13,71%
Future proof	2	1	1	2	1	3	1/4	13,71%
Costs	3	1/2	1/2	1	1/2	2	1/5	7,83%
Feasibility	4	1	1	2	1	3	1/4	13,71%
Security	5	1/3	1/3	1/2	1/3	1	1/6	4,99%
Features	6	4	4	5	4	6	1	46,05%

Table 10: AHP calculation of main categories

Matrix		Assistance user issues	Assistance technical problems	Costs of assistance	Early adoption errors	normalized principal Eigenvector
		1	2	3	4	
Assistance user issues	1	1	1	1	1	25,00%
Assistance technical problems	2	1	1	1	1	25,00%
Costs of assistance	3	1	1	1	1	25,00%
Early adoption errors	4	1	1	1	1	25,00%

Table 11: AHP calculation of support category

Matrix	Automatic updates	Expansion possibilities	Dependency on	Upcoming innovations	normalized principal Eigenvector
	1	2	3	4	
Automatic updates	1	1	3	1	$\begin{pmatrix} 30,00\% \\ 30,00\% \\ 10,00\% \\ 30,00\% \end{pmatrix}$
Expansion possibilities	2	1	3	1	
Dependency on	3	1/3	1	1/3	
Upcoming innovations	4	1	3	1	

Table 12: AHP calculation of future proof category

Matrix	One-off costs	Monthly costs	Future costs	normalized principal Eigenvector
	1	2	3	
One-off costs	1	1/5	1	$\begin{pmatrix} 14,29\% \\ 71,43\% \\ 14,29\% \end{pmatrix}$
Monthly costs	2	5	5	
Future costs	3	1	1/5	

Table 13: AHP calculation of costs category

Matrix	Time consumption	Problem potential	Programmer skills with the platform	normalized principal Eigenvector
	1	2	3	
Time consumption	1	1/2	1	$\begin{pmatrix} 25,00\% \\ 50,00\% \\ 25,00\% \end{pmatrix}$
Problem potential	2	1	2	
Programmer skills with	3	1/2	1	

Table 14: AHP calculation of feasibility category

Matrix				normalized principal Eigenvector
	Server security	Platform security	User security	
Server security	1	1	1	33,33%
Platform security	2	1	1	
User security	3	1	1	

Table 15: AHP calculation of security category

Matrix															normalized principal Eigenvector
	Database	Adding propertie	Work hour plann	fill in speed	loading speed	Work simultaneo	ease of use	Learning curve	Financial insight	Accessability of sy	Logistics	import/export in	Link with financi	Budget planning	
Database	1	1	1	1/2	3	4	1/2	1	1/2	4	1/2	3	3	3	7,84%
Adding properties	2	1	1	1/2	3	4	1/2	1	1/2	4	1/2	3	3	3	7,84%
Work hour planning	3	1	1	1/2	3	4	1/2	1	1/2	4	1/2	3	3	3	7,84%
fill in speed	4	2	2	1	4	5	1	2	1	5	1	4	4	4	13,01%
loading speed	5	1/3	1/3	1/3	1/4	1	2	1/4	1/3	1/4	2	1/4	1	1	3,14%
Work simultaneous	6	1/4	1/4	1/4	1/5	1/2	1	1/5	1/4	1/5	1	1/5	1/2	1/2	2,03%
ease of use	7	2	2	2	1	4	5	1	2	5	1	4	4	4	13,01%
Learning curve	8	1	1	1	1/2	3	4	1/2	1	1/2	4	1/2	3	3	7,84%
Financial insight	9	2	2	2	1	4	5	1	2	1	5	1	4	4	13,01%
Accessability of syst	10	1/4	1/4	1/4	1/5	1/2	1	1/5	1/4	1/5	1	1/5	1/2	1/2	2,03%
Logistics	11	2	2	2	1	4	5	1	2	1	5	1	4	4	13,01%
import/export in ot	12	1/3	1/3	1/3	1/4	1	2	1/4	1/3	1/4	2	1/4	1	1	3,14%
Link with financial	13	1/3	1/3	1/3	1/4	1	2	1/4	1/3	1/4	2	1/4	1	1	3,14%
Budget planning	14	1/3	1/3	1/3	1/4	1	2	1/4	1/3	1/4	2	1/4	1	1	3,14%

Table 16: AHP calculation of features category

With all weights set and the solutions graded according to the explanation given in chapter 6, the total scores of the solutions can be calculated. The total score of every option is calculated according to the following formula:

$$\text{Total score of option} = \sum (\text{weight of section} * (\sum (\text{weight of criteria} * \text{score of criteria})))$$

So, every weight of a criteria gets multiplied with the score of every criterion. Then you take the sum of all of those weighted scores for a section. Then you multiply the summed up weighted scores of a section with the weight of the section. Then lastly you sum up all the weighted scores of every section and then you have the total score of an option. All these calculations can be seen in table 17 that can be seen below.

Evaluation Criteria																					
Goal: Selecting most appropriate all-in-one Project Planning solution																					
Option 1: ERP PDC Option 2: Excel + SQL Option 3: Mendix Option 4: Zoho Option 5: Full development with a framework Option 6: Spendmap Option 7: Odoo Option 8: Exact Option 9: Bizagi Studio Option 10: Microsoft dynamics 365																					
Rating Rules: Rate each criteria from a scale 1-5;																					
Support																					
Category weight:	13.71%	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Option 10	
	Item wgtg	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value
1 Help/assistance user issues	25,00%	5	1,25	2	0,5	3	0,75	4	1	2	0,5	4	1	4	1	4	1	3	0,75	4	1
2 Help/assistance technical problems	25,00%	5	1,25	4	1	4	1	4	1	3	0,75	4	1	4	1	4	1	4	1	4	1
3 Costs of assistance	25,00%	3	0,75	2	0,5	3	0,75	3	0,75	2	0,5	3	0,75	3	0,75	3	0,75	3	0,75	3	0,75
4 Early adoption errors	25,00%	4	1	2	0,5	2	0,5	3	0,75	2	0,5	4	1	3	0,75	3	0,75	2	0,5	4	1
Total Performance		0,582675		0,34275		0,4113		0,47985		0,308475		0,51413		0,47985		0,47985		0,4113		0,514125	
Future proof																					
Category weight:	13.71%	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Option 10	
	Item wgtg	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value
1 Automatic updates	30,00%	4	1,2	2	0,6	3	0,9	3	0,9	2	0,6	3	0,9	3	0,9	3	0,9	3	0,9	4	1,2
2 Expansion possibilities	30,00%	1	0,3	4	1,2	3	0,9	3	0,9	5	1,5	1	0,3	3	0,9	3	0,9	3	0,9	3	0,9
3 Dependency on	10,00%	3	0,3	4	0,4	3	0,3	3	0,3	4	0,4	3	0,3	3	0,3	3	0,3	3	0,3	4	0,4
4 Upcoming Innovations	30,00%	4	1,2	2	0,6	3	0,9	3	0,9	2	0,6	3	0,9	3	0,9	3	0,9	3	0,9	3	0,9
Total Performance		0,4113		0,38388		0,4113		0,4113		0,42501		0,32904		0,4113		0,4113		0,4113		0,46614	
Costs																					
Category weight:	7.83%	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Option 10	
	Item wgtg	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value
1 One-off costs	14,29%	1	0,1429	4	0,5716	4	0,5716	4	0,5716	4	0,5716	4	0,5716	4	0,5716	4	0,5716	2	0,2858	5	0,7145
2 Montly costs	71,43%	2	1,4286	4	2,8572	3	2,1429	3	2,1429	4	2,8572	4	2,8572	2	1,4286	1	0,7143	2	1,4286	2	1,4286
3 Future costs	14,29%	5	0,7145	4	0,5716	4	0,5716	4	0,5716	4	0,5716	5	0,7145	5	0,7145	5	0,7145	5	0,7145	5	0,7145
Total Performance		0,178994		0,313231		0,257302		0,2573		0,313231		0,32442		0,21256		0,15663		0,190183		0,22375	
Feasibility																					
Category weight:	13.71%	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Option 10	
	Item wgtg	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value
1 Time consumption	25,00%	5	1,25	2	0,5	3	0,75	2	0,5	1	0,25	5	1,25	3	0,75	4	1	3	0,75	4	1
2 Problem potential	50,00%	5	2,5	3	1,5	2	1	3	1,5	3	1,5	5	2,5	3	1,5	4	2	2	1	4	2
3 Programmer skills with the platform	25,00%	4	1	5	1,25	3	0,75	2	0,5	1	0,25	5	1,25	3	0,75	4	1	2	0,5	3	0,75
Total Performance		0,651225		0,445575		0,34275		0,34275		0,2742		0,6855		0,4113		0,5484		0,308475		0,514125	
Security																					
Category weight:	4.99%	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Option 10	
	Item wgtg	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value
1 Server security	33,33%	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333
2 Platform security	33,33%	4	1,333333	3	1	5	1,666667	4	1,333333	5	1,666667	4	1,333333	4	1,333333	4	1,333333	4	1,333333	4	1,333333
3 User security	33,33%	3	1	4	1,333333	5	1,666667	4	1,333333	5	1,666667	3	1	3	1	3	1	4	1,333333	4	1,333333
Total Performance		0,182967		0,182967		0,232867		0,1996		0,232867		0,18297		0,18297		0,18297		0,1996		0,1996	
Features																					
Category weight:	46.05%	Option 1		Option 2		Option 3		Option 4		Option 5		Option 6		Option 7		Option 8		Option 9		Option 10	
	Item wgtg	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value	Item rating	Item value
1 Database	7,84%	4	0,313422	5	0,391777	4	0,313422	4	0,31342	5	0,391777	4	0,31342	4	0,31342	4	0,31342	4	0,31342	4	0,313422
2 Adding properties	7,84%	3	0,235066	5	0,391777	5	0,391777	5	0,39178	5	0,391777	2	0,15671	5	0,39178	3	0,23507	5	0,391777	4	0,313422
3 Work hour planning creation	7,84%	3	0,235066	5	0,391777	5	0,391777	4	0,31342	5	0,391777	1	0,07836	3	0,23507	2	0,15671	5	0,391777	2	0,156714
4 Fill in speed	13,01%	3	0,390234	5	0,650391	5	0,650391	4	0,52031	5	0,650391	3	0,39023	4	0,52031	4	0,52031	5	0,650391	3	0,390234
5 loading speed	3,14%	5	0,157032	3	0,094219	5	0,157032	5	0,15703	5	0,157032	5	0,15703	5	0,15703	5	0,15703	5	0,157032	5	0,157032
6 Work simultaneously	2,03%	5	0,101601	3	0,06096	5	0,101601	5	0,1016	4	0,08128	5	0,1016	5	0,1016	5	0,1016	5	0,101601	5	0,101601
7 ease of use	13,01%	4	0,520312	5	0,650391	4	0,520312	5	0,65039	5	0,650391	4	0,52031	4	0,52031	4	0,52031	4	0,520312	4	0,520312
8 Learning curve	7,84%	4	0,313422	5	0,391777	3	0,235066	3	0,23507	3	0,235066	4	0,31342	3	0,23507	3	0,23507	3	0,235066	3	0,235066
9 Financial insight	13,01%	3	0,390234	5	0,650391	4	0,520312	4	0,52031	5	0,650391	2	0,26016	4	0,52031	4	0,52031	4	0,520312	4	0,520312
10 Accessibility of system components	2,03%	2	0,04064	5	0,101601	5	0,101601	4	0,08128	5	0,101601	1	0,02032	3	0,06096	3	0,06096	5	0,101601	2	0,04064
11 Logistics	13,01%	4	0,520312	4	0,520312	3	0,390234	5	0,65039	5	0,650391	4	0,52031	4	0,52031	4	0,52031	3	0,390234	4	0,520312
12 Import/export in other files/program	3,14%	4	0,125626	5	0,157032	3	0,094219	4	0,12563	5	0,157032	3	0,09422	4	0,12563	4	0,12563	3	0,094219	4	0,125626
13 Link with financial administration	3,14%	4	0,125626	2	0,062813	2	0,062813	5	0,15703	2	0,062813	1	0,03141	5	0,15703	5	0,15703	2	0,062813	4	0,125626
14 Budget planning	3,14%	3	0,094219	4	0,125626	4	0,125626	4	0,12563	4	0,125626	3	0,09422	3	0,09422	4	0,125626	3	0,094219	3	0,094219
Total Performance		1,640675		2,137108		1,867872		2,00008		2,163127		1,46522		1,82038		1,71213		1,867872		1,664494	
Total																					
Category	Weight	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10										
Support	13.71%	0.583	0.343	0.411	0.480	0.308	0.514	0.480	0.480	0.411	0.514										
Future proof	13.71%	0.411	0.384	0.411	0.411	0.425	0.329	0.411	0.411	0.411	0.466										
Costs	7.83%	0.179	0.313	0.257	0.257	0.313	0.324	0.213	0.157	0.190	0.224										
Feasibility	13.71%	0.651	0.446	0.343	0.343	0.274	0.686	0.411	0.548	0.308	0.514										
Security	4.99%	0.183	0.183	0.233	0.200	0.233	0.183	0.183	0.183	0.200	0.200										
Features	46.05%	1.641	2.137	1.868	2.000	2.163	1.465	1.820	1.712	1.868	1.664										
Total	100,00%	3,648	3,806	3,523	3,691	3,717	3,501	3,518	3,491	3,389	3,582										

Table 17: Complete MCDA elaboration

Appendix C: New workflow models

In this appendix all models of the new procurement and assemblage workflow can be found. This encompasses the complete new workflow and all its sub processes. In the figures below can all these models be found.

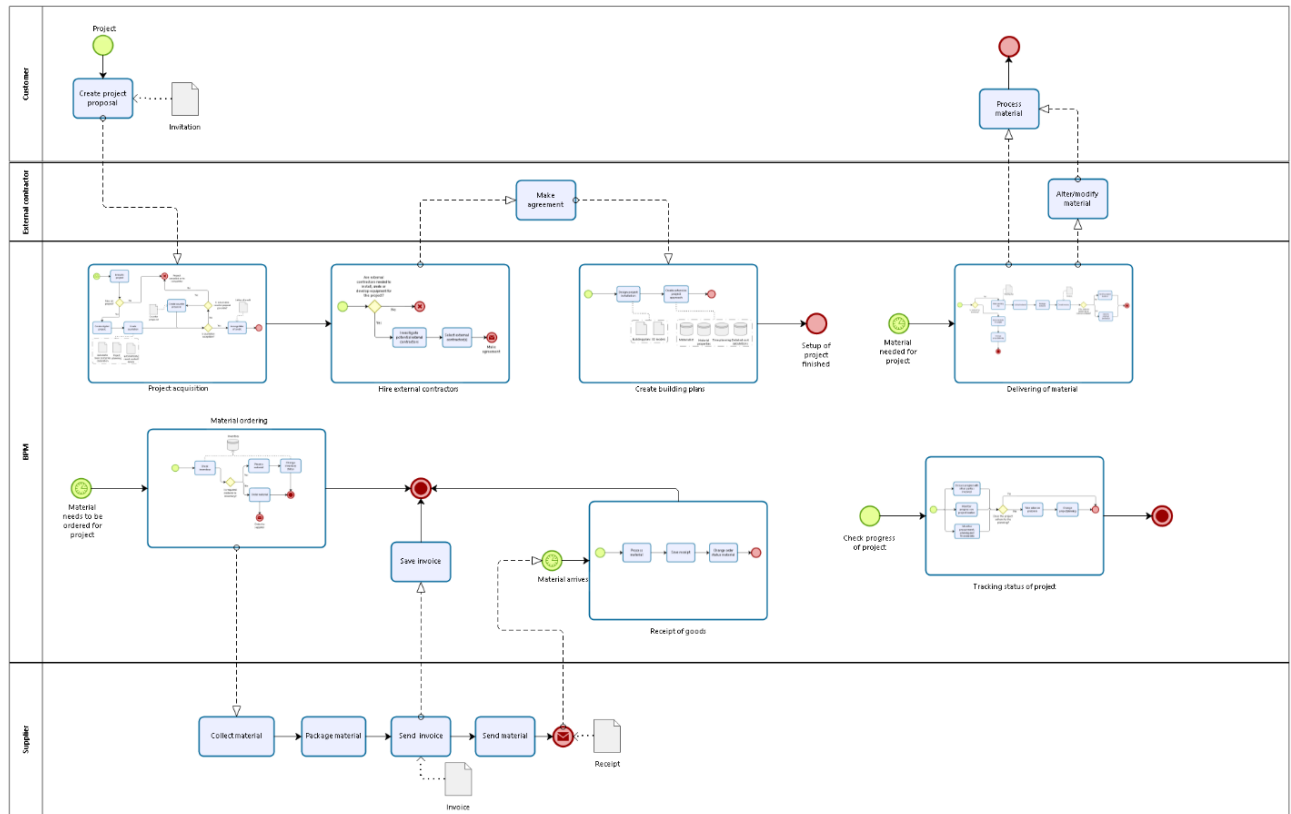


Figure 23: Complete new workflow

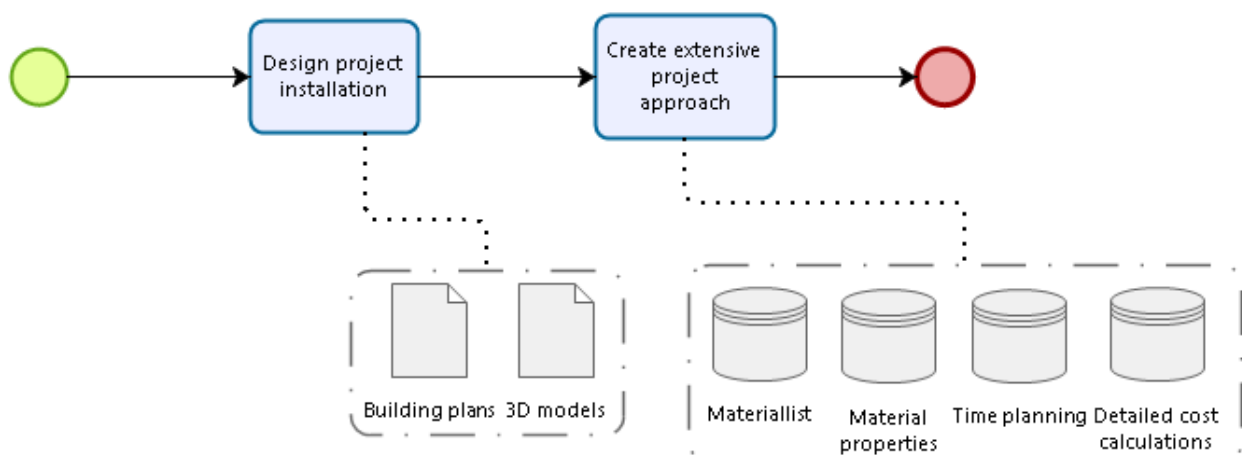


Figure 24: Project acquisition – New model

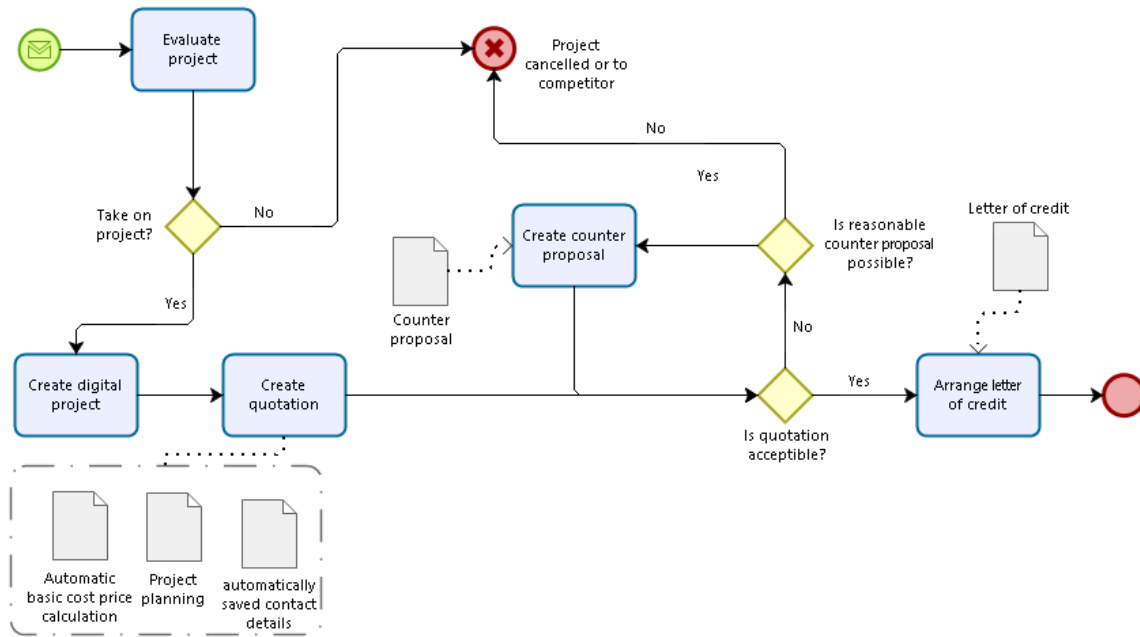


Figure 25: Create building plans – New model

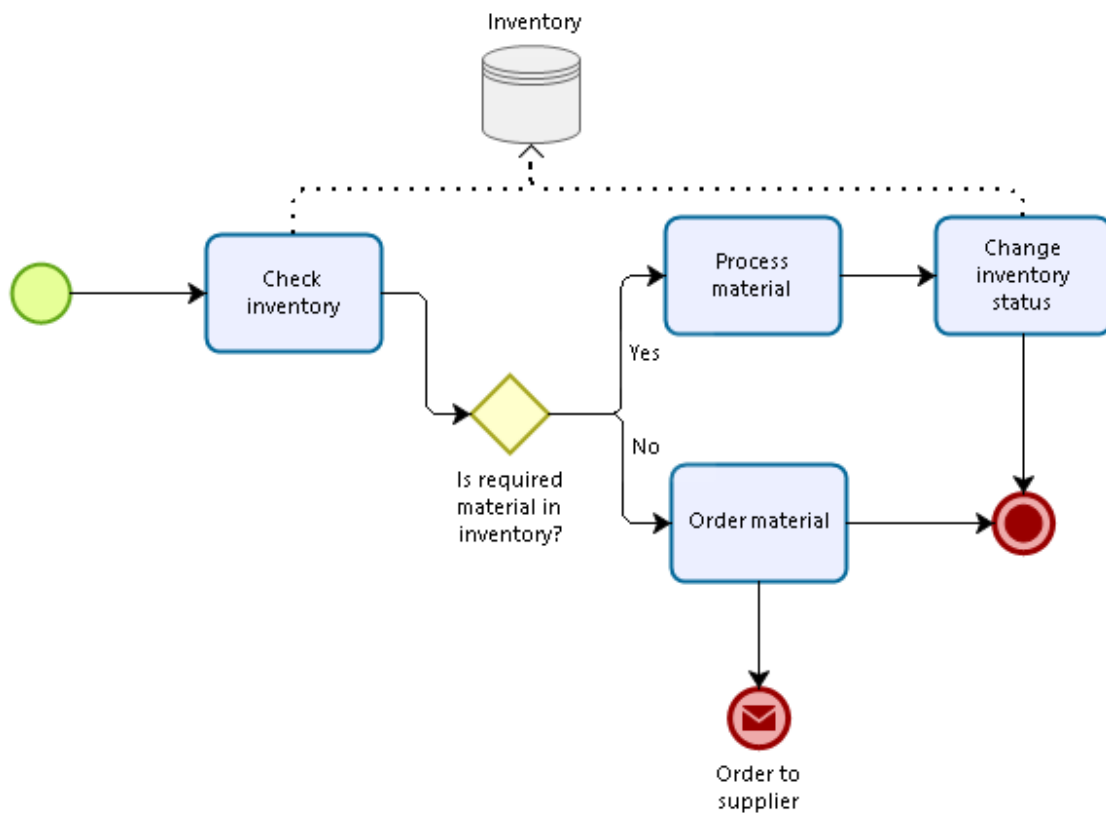


Figure 26: Material ordering – New model

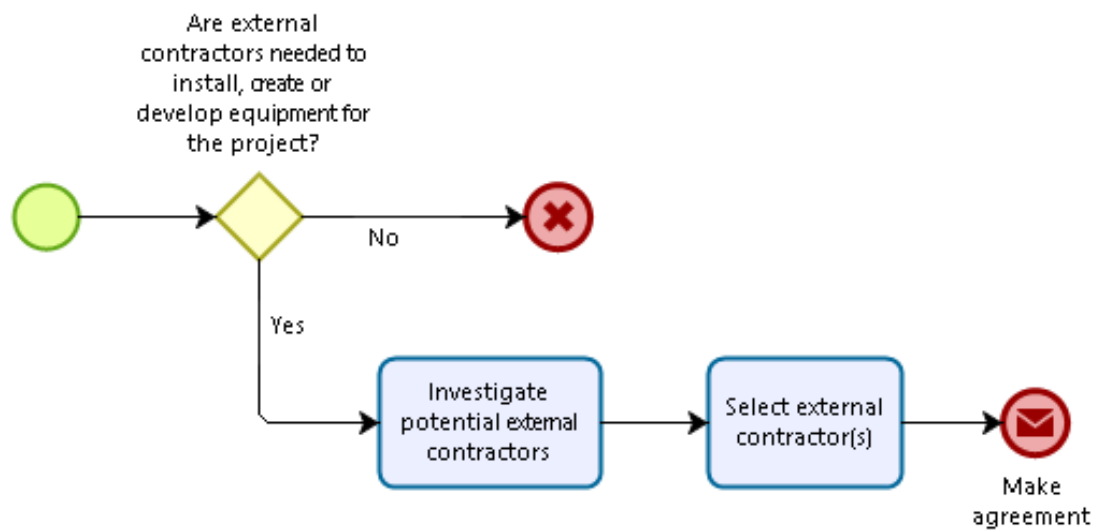


Figure 27: Hire external contractors – New model



Figure 28: Receipt of goods – New model

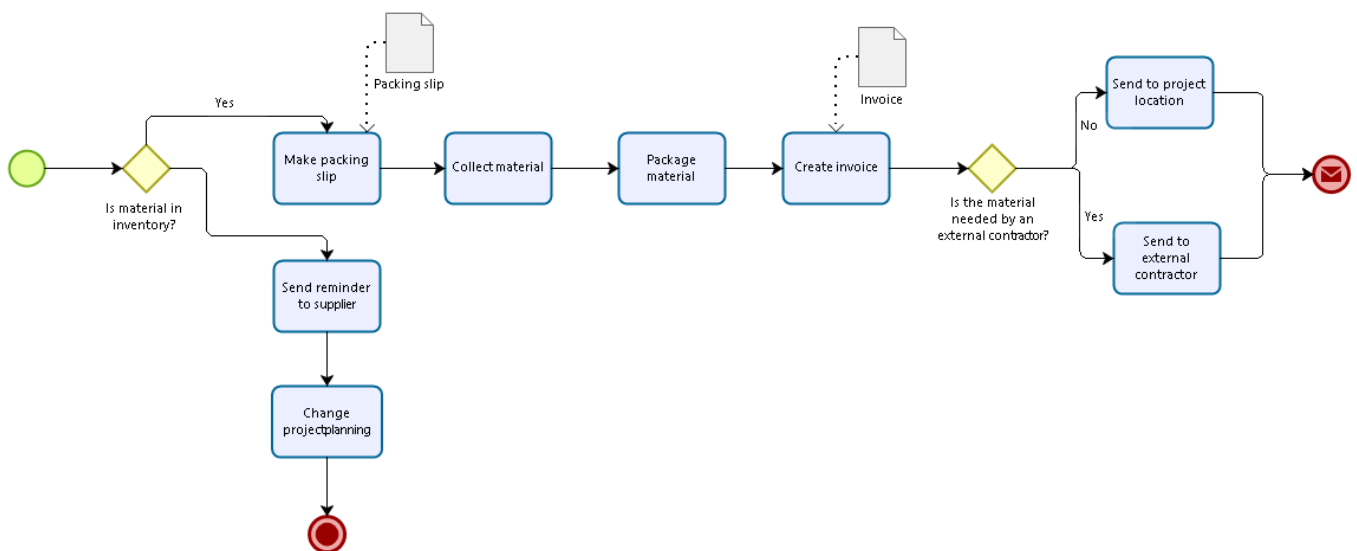


Figure 29: Delivering of material – New model

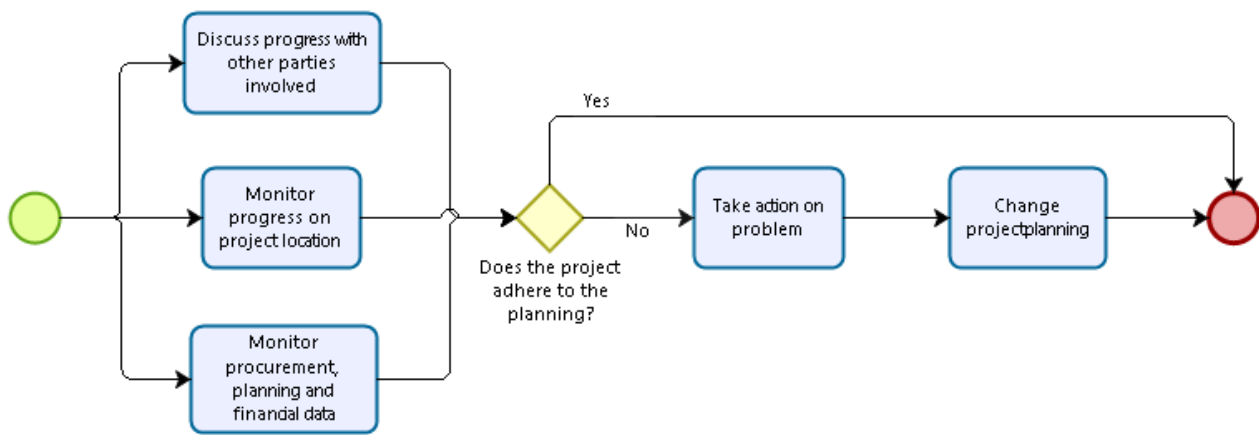


Figure 30: Tracking of project – New model

Appendix D: User instruction manual for the artifact

In this appendix I will give an explanation of how to use the artifact and all functions it possesses. This is an instruction for the user on how to use the platform and not on how the functions were coded/developed. More summarized information about the underlying code and innerworkings of the functions can be found in chapter 8.

The manual will start in appendix D.a with information about the functionality of the homepage and give info about where to find information in this manual according to the layout of the homepage. Appendix D.b offers information about how to add/modify/delete and/or view contact info, material info, price info and valuta info out of the database. It also offers information about how to set up a database and connect it to the artifact. Appendix D.c offers information about how to add/modify/delete and/or view project info out of the database. Appendix D.c also gives information about where a project is used for and how to manage a project in the artifact throughout every stage of the project. Appendix D.d offers information about the functionality of the material list. It explains how to use the material list and how the material list is connected to other parts of the artifact. Appendix D.e offers information about how purchase orders, confirmation of orders, packing slips and receipts can be created and managed. Appendix D.f explains what for information the financial overview offers. By reading all six of these chapters you will have the knowledge that is needed to understand and use this artifact.

Appendix D.a Homepage

The homepage of the artifact gives an overview over almost all functions that the artifact offers. The homepage is set up to give access to all functions and is also used as stopover to go from one part of the artifact to another part of the artifact. The homepage also offers summarized information about the current state of the company and their operations.

All chapters of this appendix cover a different part/functionality of the artifact. To get a clear view of how all these functions are connected to the homepage and where to find information according to the homepage, have a look at figure 31 below.

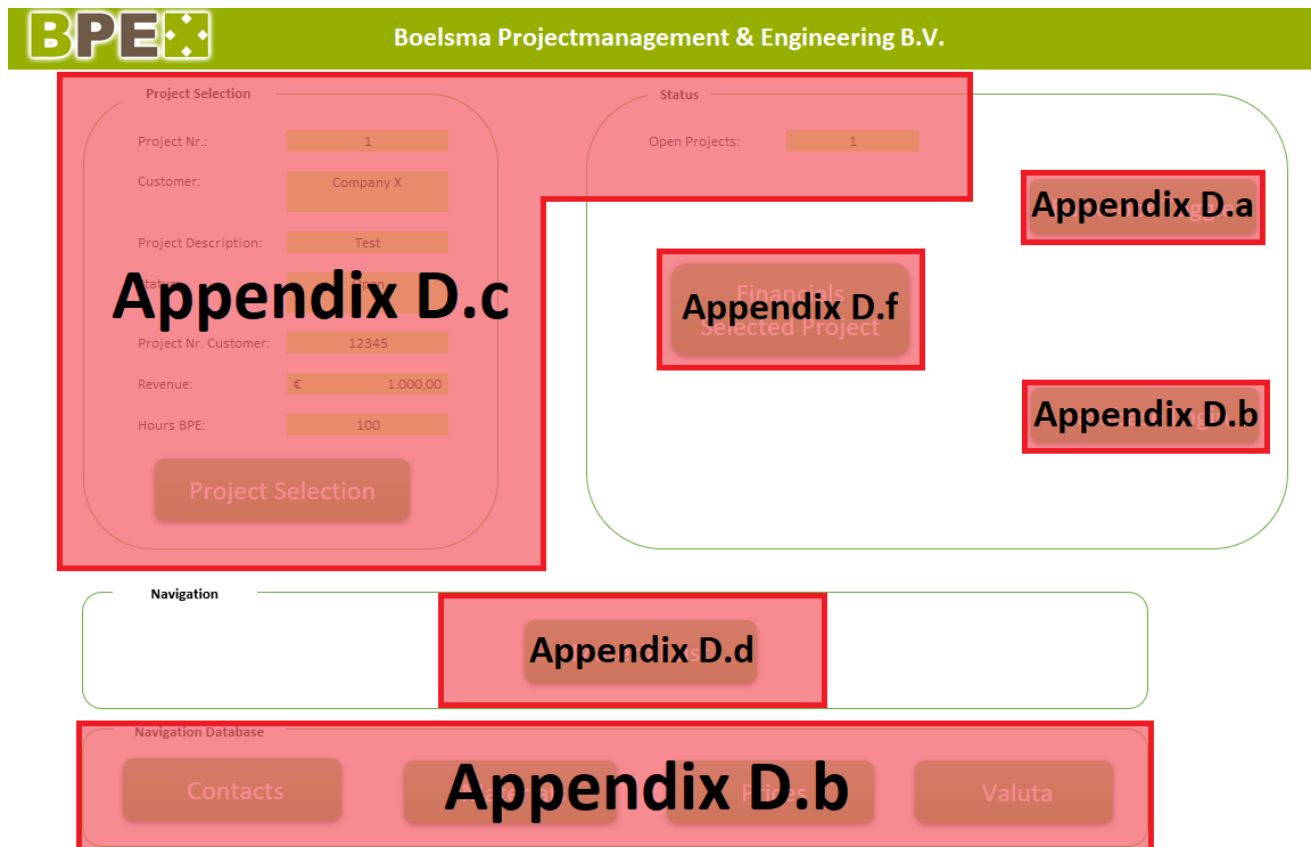


Figure 31: Homepage overview

Appendix D.a.a Backdoor Toggle

The only direct function that the homepage offers which is not linked to another part of the artifact is the backdoor visibility. This function is directly activated by pressing the 'Backdoor Toggle' button on the homepage. This button can be found in the left upper corner of the status section of the homepage.

By pressing this button you make all background data/text visible in Excel which is used to store and execute code/functions from the artifact. By pressing this button again you hide this background data/text again. This button should only be used when developing the artifact or when errors in the database system need to be fixed. This background data/text is used in different functions and worksheets throughout the application and visibility of all this data/text is controlled with this button. An example of the effect of this button can be seen below in figure 32.

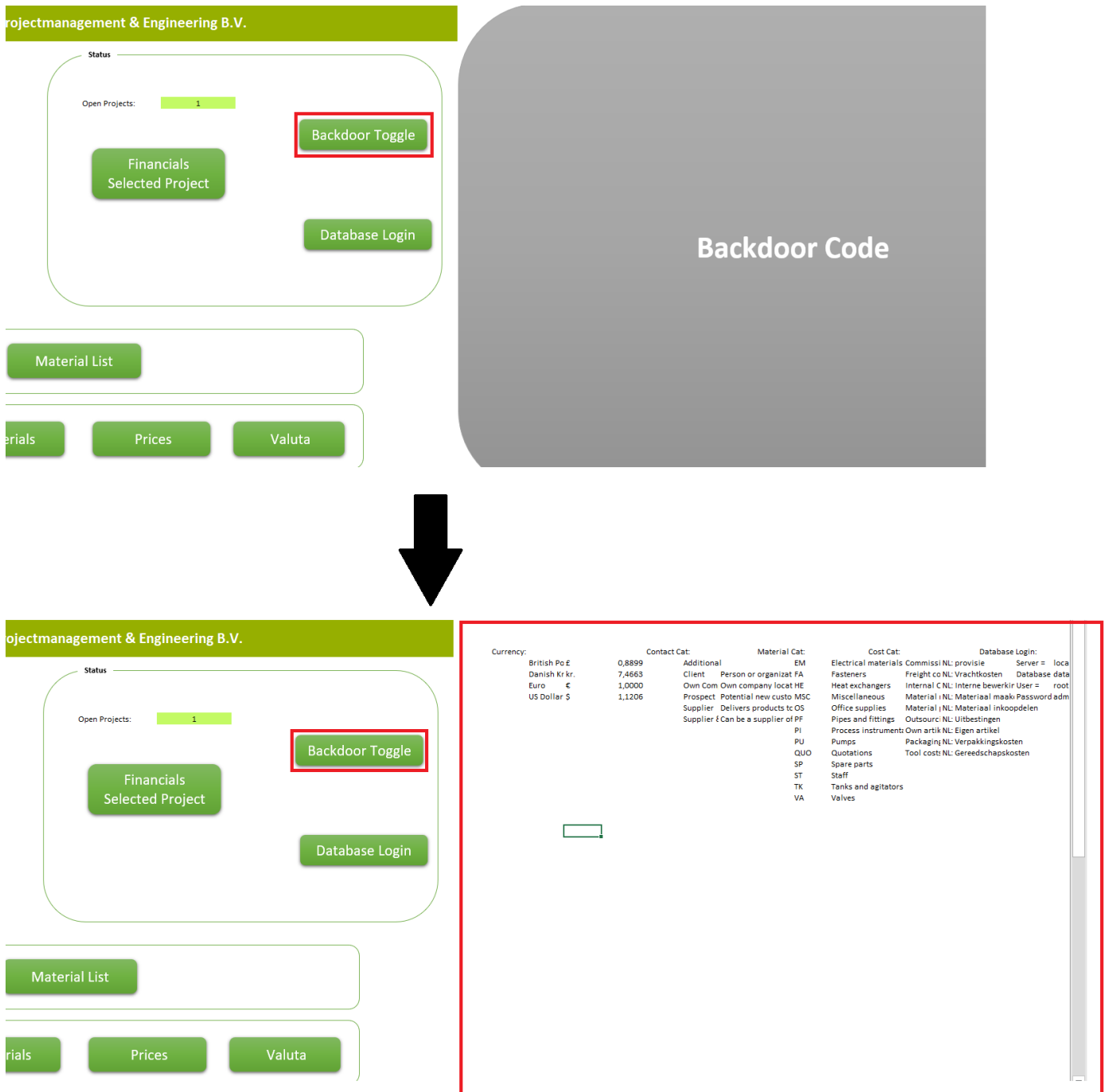


Figure 32: Backdoor toggle feature

Appendix D.b Database

A database needs to be connected to the artifact to let it function. This needs to be a SQL-based database. This type of database can be set up with different applications. Some widely used applications that could provide such a database are Oracle MySQL, Microsoft SQL and Microsoft Access. A database needs to be set up to the exact structure that it was built for. It is not possible to connect a database with a different structure, because then certain features will not perform correctly. A lot of features are intertwined and this can even lead to a failure of all functions of the application. So, be very careful when setting up a database.

The database has to be set up according to the structure that can be found below in figure 33. It is very important that the tables and columns exactly match up with the structure. The names should exactly match up with the figure, because otherwise the functions of the artifact cannot find the correct column to transfer data. The data types should also exactly match the figure, only changes can be made to the maximum size of the column. So the maximum amount of characters that a value can hold can be changed. This will then change the maximum size you can pass from the application to the database. This will also change the size of the data the database needs to store and can improve the performance of the database when decreasing the size of the maximum size of a column. The maximum size of the columns in the figure should provide a good guideline in setting these values.

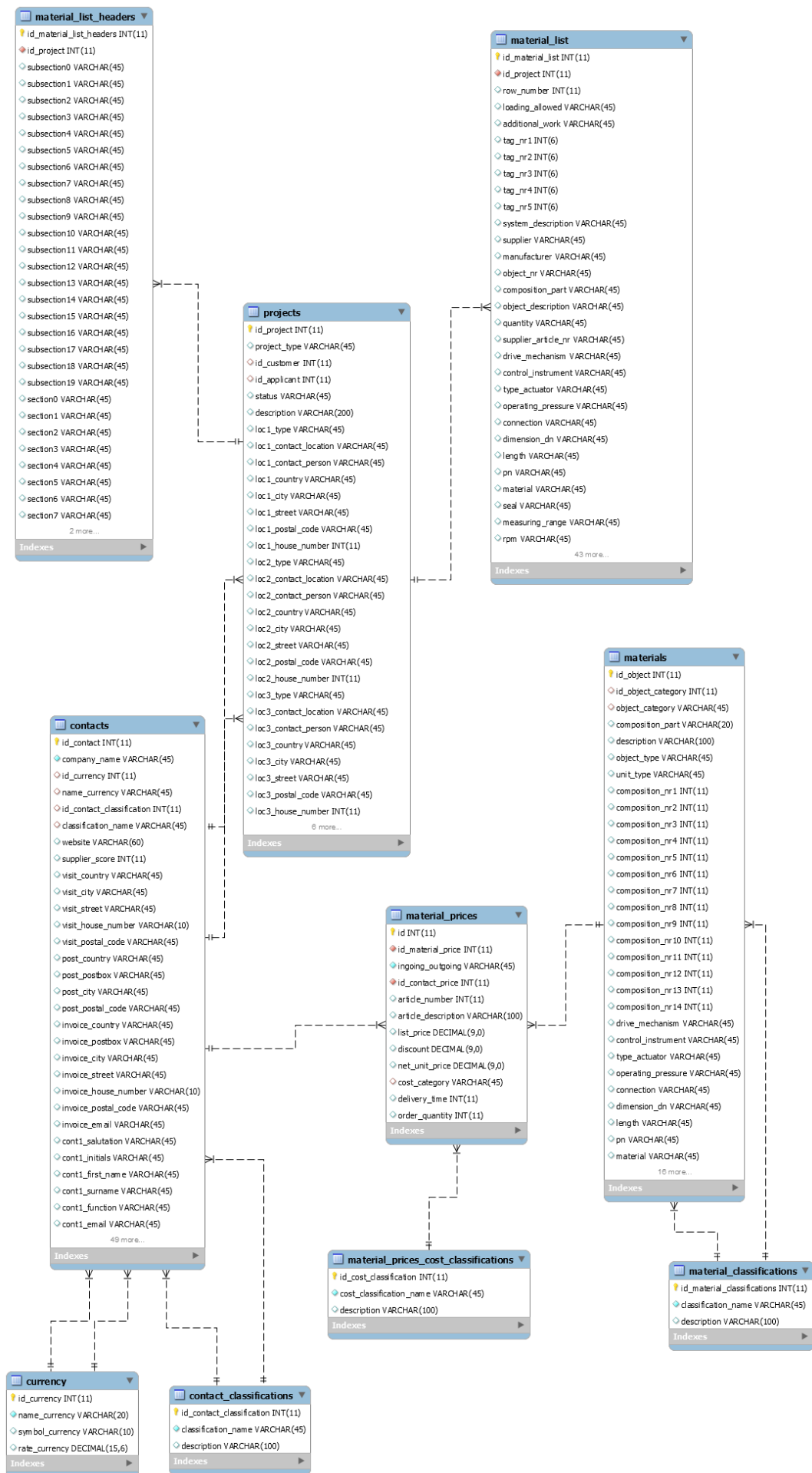


Figure 33: Database structure

Appendix D.b.a Database connection

When the database is created it can be connected to the artifact. Before connecting a new database it is important that some database details are removed from the artifact if it is or was connected to another database. This is the case because the artifact stores small parts of the database in the artifact to speed up some actions in the artifact. The database details that need to be deleted are: Currency data, contact category data, material category data and cost category data. This can be done in two different ways. Firstly by deleting this data out of the previous database. How to do this can be found in the other sections of this chapter. Secondly by removing the details directly from the spot where the data is stored. For this you have to use the backdoor toggle as explained in appendix D.a.a. In the homepage you can find all this data at the right of the page behind the backdoor you can disable with the backdoor toggle. You can delete all this data except the titles on row 1 and the database login info on column AH and AI. So, cells V2 to the last row of AG can be deleted. Connecting a database that has already data entries in one of these categories is also not possible. Only by entering this data behind the backdoor on the homepage can a database with already this type of entries correctly be connected. So be careful that the data entries in the database line up with the saved data in the artifact.

If the database is created and matches the data of the artifact it can be connected to the artifact. The server name, database name, username and password of the database are required for connecting the database. These details should have been obtained when creating the database. The details can be entered when pressing the 'Database Login' button on the home screen. The 'Database Login' button is located in the right upper corner of the homepage, below the 'Backdoor Toggle' button. An example of entering these details can also be found in figure 34, which can be found below. Note that the artifact gives a safety message because a faulty database can cause problems in the artifact.

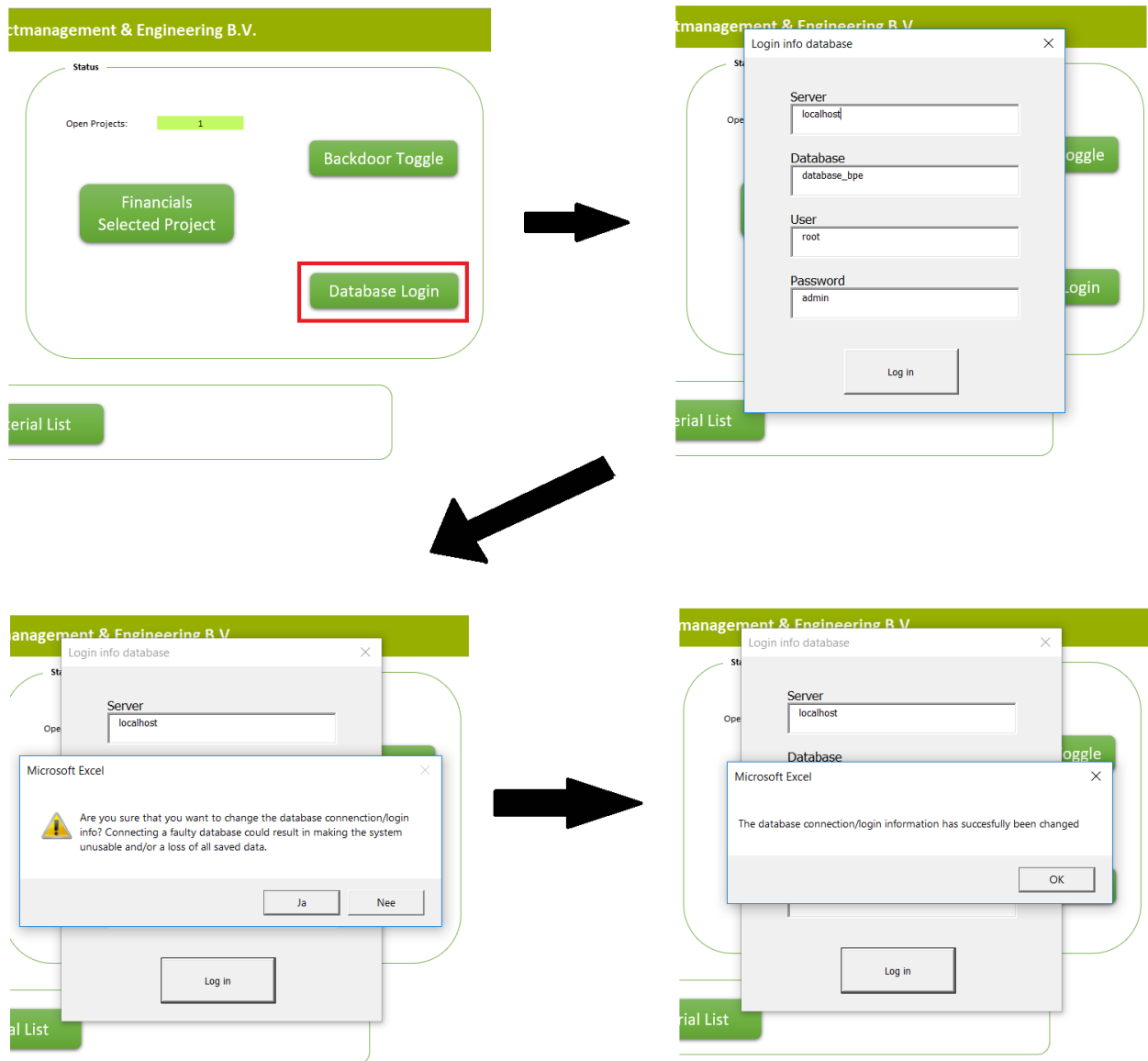


Figure 34: Connecting a database

Appendix D.b.b Contacts

Contact details can be entered into the database from the artifact. Note that before entering contact details into your database you have correctly connected a SQL database to the artifact according to steps described earlier in this chapter. These details can be entered by pressing the 'Contacts' button that is located in the lower left corner of the homepage. Pressing this button opens up a navigation screen that gives the possibility to open up the possibility to add/modify or delete 2 types of contact info. It also gives the possibility to show all contacts.

By pressing the 'Add Contact' button in the navigation screen you open up a form page at which you can enter a new contact with all details of this contact. The form page has 4 control buttons at the top of the screen and below that a form in which the user can add all

details of the contact. For a quick overview of how this page works please also have a look at figure 35, which can be found below.

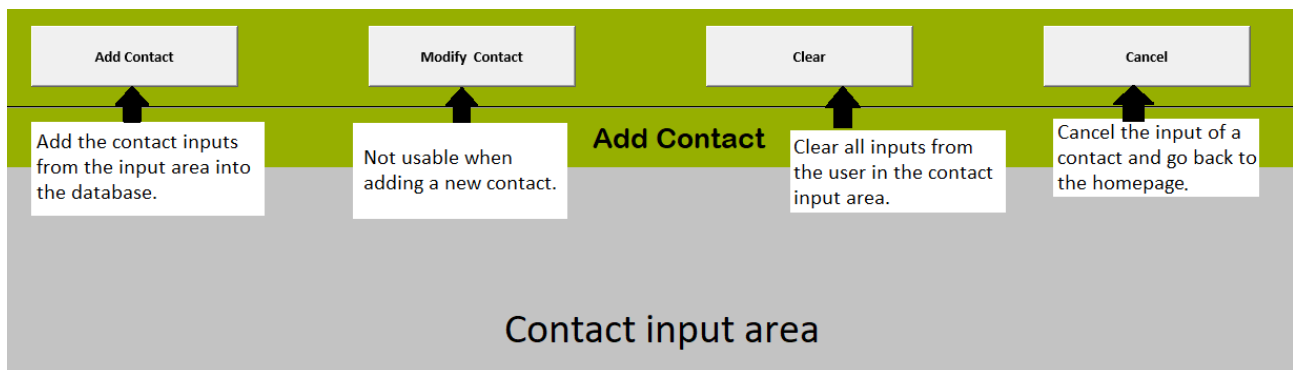


Figure 35: Adding a new contact

By pressing the 'Modify/Delete Contact' button in the navigation screen you open up a page with an overview of all contacts in the background and a quick selection pop-up screen on the foreground. From here on you can use the quick selection pop-up screen to modify and delete a contact or go to the overview of all contacts and from there select a contact. If you then press the 'Modify Contacts' button the system will pre-select the corresponding contact in the quick selection pop-up screen that will appear again.

By pressing the 'Add Contact Category' button in the navigation screen you open up an input pop-up screen. In this screen you can enter contact categories you want to use to categorize different types of contacts. This can help in filtering and/or selecting contacts for different tasks in the artifact. Press the confirm button on the bottom of the pop-up screen to save the entered name and description to the database.

By pressing the 'Modify/Delete Contact Category' button in the navigation screen you open up a pop-up screen. This pop-up screen has a selection section on the right, which shows all contact categories that are already entered into the system. Select a contact category from this selection section that you want to modify or delete. After that press the delete button in the lower right corner of the pop-up screen to delete this contact category out of the database. If you want to change the name or the description of the contact category you can do that by changing this in the right textboxes after selection the corresponding contact category on the left. To confirm the changes you have to press the change button at the bottom of the pop-up screen.

By pressing the 'Show Contacts' button in the navigation screen you go to an overview page of all contacts that are currently saved into the database. You can see all details of the contacts added and can also filter on different contact details. From this screen you also have the possibility to add a new contact or modify an existing contact just as described earlier in this section. You have also the possibility to add a price from this overview page. More details about this function are discussed in appendix D.b.d. For a quick overview of how this page works please also have a look at figure 36, which can be found below.

	Home		Modify Contacts		Add Contact		Add Price	
Control	Company Details						Visit Address	
	ID Contact: <input type="text"/>	Company Name: <input type="text"/>	ID Currency: <input type="text"/>	Currency: <input type="text"/>	ID Contact Catego: <input type="text"/>	Company Catego: <input type="text"/>	Website: <input type="text"/>	Supplier Scor: <input type="text"/>
							Country: <input type="text"/>	City: <input type="text"/>
							Street: <input type="text"/>	House Num: <input type="text"/>
							Postal Cod: <input type="text"/>	
Select	Go back to the homepage		Modify selected contact		Add a new contact		Add a price for a material of the selected supplier	
Select	Contact details							
Select								
Select								

Figure 36: Contact overview

Appendix D.b.c Materials

Material details can be entered into the database from the artifact. Note that before entering material details into your database you have correctly connected a SQL database to the artifact according to steps described earlier in this chapter. These details can be entered by pressing the 'Materials' button that is located on the bottom of the homepage. Pressing this button opens up a navigation screen that gives the possibility to open up the possibility to add/modify or delete 2 types of material info. It also gives the possibility to show all materials.

By pressing the 'Add Material' button in the navigation screen you open up a form page at which you can enter a new material with all details of the material. The form page has 4 control buttons at the top of the screen and below that a form in which the user can add all details of the material. For a quick overview of how this page works please also have a look at figure 37, which can be found below.

Add Material	Modify Material	Clear	Cancel
↑	↑	↑	↑
Add the material inputs from the input area into the database.	Not usable when adding a new material.	Add Material	Clear all inputs from the user in the material input area.
			Cancel the input of a material and go back to the homepage.
Material input area			

Figure 37: Adding a new material

By pressing the 'Modify/Delete Material' button in the navigation screen you open up a page with an overview of all materials in the background and a quick selection pop-up screen on the foreground. From here on you can use the quick selection pop-up screen to modify and delete a material or go to the overview of all contacts and from there select a material. If you then press the 'Modify Material' button the system will pre-select the corresponding material in the quick selection pop-up screen that will appear again.

By pressing the 'Add Material Category' button in the navigation screen you open up an input pop-up screen. In this screen you can enter contact categories you want to use to categorize different types of contacts. This can help in filtering and/or selecting contacts for different tasks in the artifact. Press the confirm button on the bottom of the pop-up screen to save the entered name and description to the database.

By pressing the 'Modify/Delete Material Category' button in the navigation screen you open up a pop-up screen. This pop-up screen has a selection section on the right, which shows all contact categories that are already entered into the system. Select a contact category from this selection section that you want to modify or delete. After that press the delete button in the lower right corner of the pop-up screen to delete this contact category out of the database. If you want to change the name or the description of the contact category you can do that by changing this in the right textboxes after selection the corresponding contact category on the left. To confirm the changes you have to press the change button at the bottom of the pop-up screen.

By pressing the 'Show Materials' button in the navigation screen you go to an overview page of all contacts that are currently saved into the database. You can see all details of the contacts added and can also filter on different contact details. From this screen you also have the possibility to add a new contact or modify an existing contact just as described earlier in this section. You have also the possibility to add a price from this overview page. More details about this function are discussed in appendix D.b.d. For a quick overview of how this page works please also have a look at figure 38, which can be found below.

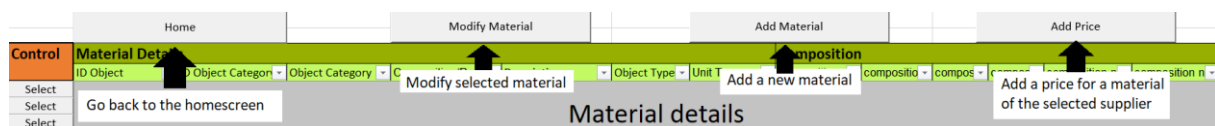


Figure 38: Material overview

Appendix D.b.d Prices

Pricing details can be entered into the database from the artifact. Note that before entering pricing details into your database you have correctly connected a SQL database to the artifact according to steps described earlier in this chapter. These details can be entered by pressing the 'Prices' button that is located on the bottom of the homepage. Pressing this button opens up a navigation screen that gives the possibility to open up the possibility to add/modify cost category info. It also gives the possibility to add and manage price info.

By pressing the 'Add Price' button in the navigation screen you open up a form page at which you can enter a new price for a material of a supplier. Before entering a price the user should have entered the material and supplier already according to the previously mentioned steps. The form page offers 4 control buttons at the top of the screen so the user can add save, modify or delete pricing details. Below the control buttons is a form located in which the user can add the pricing details. This form offers both a selection button to select the material and the supplier for which the price applies. Pressing the corresponding selection button opens up a list with all materials or suppliers from which one can be chosen. For a quick overview of how this page works please also have a look at figure 39, which can be found below.

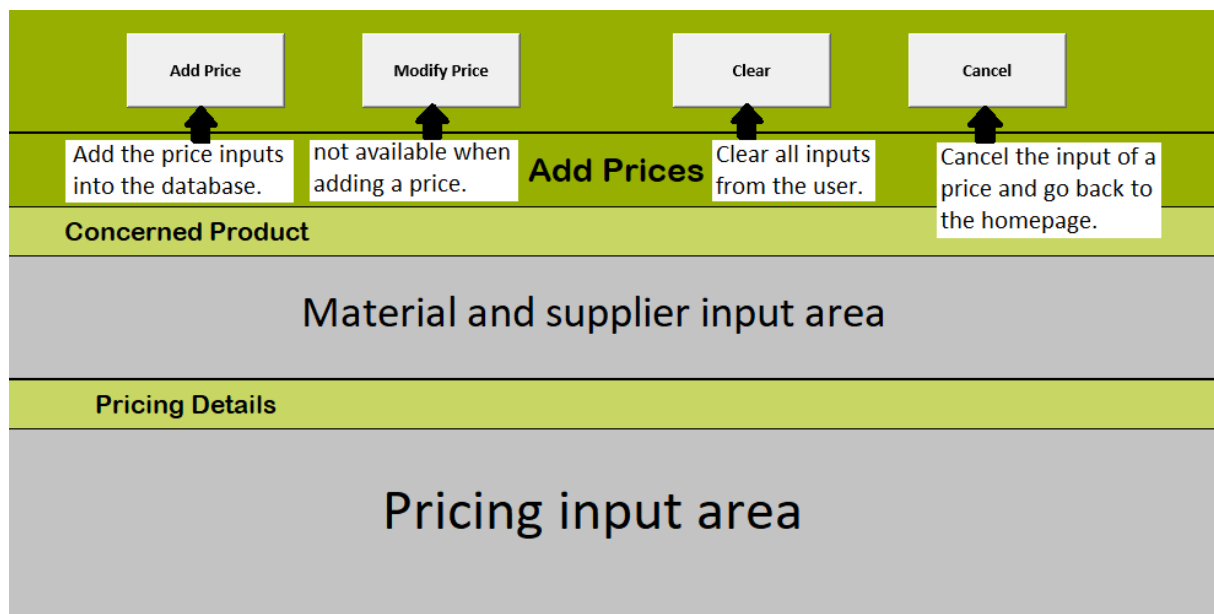


Figure 39: Adding a new price

By pressing the 'Manage Prices' button in the navigation screen you open up a page with an overview of all prices. In the overview page you can select a price with the selection buttons in the first column and then use one of the control buttons at the top of the screen to perform an action. The top control buttons consist of a 'Home', 'Modify Price' and 'Add Price' button.

By pressing the 'Add Cost Category' button in the navigation screen you open up an input pop-up screen. In this screen you can enter cost categories you want to use to categorize different types of pricing. This can help in filtering and/or selecting different types of activities/materials that induce a type of cost. Press the confirm button on the bottom of the pop-up screen to save the entered name and description to the database.

By pressing the 'Modify/Delete Cost Category' button in the navigation screen you open up a pop-up screen. This pop-up screen has a selection section on the right, which shows all cost categories that are already entered into the system. Select a cost category from this selection section that you want to modify or delete. After that press the delete button in the lower right corner of the pop-up screen to delete this contact category out of the database. If you want to change the name or the description of the contact category you can do that by changing this in the right textboxes after selection the corresponding cost category on the left. To confirm the changes you have to press the change button at the bottom of the pop-up screen.

Appendix D.b.e Valuta

Valuta details can be entered into the database from the artifact. Note that before entering valuta details into your database you have correctly connected a SQL database to the artifact according to steps described earlier in this chapter. These details can be entered by pressing the 'Valuta' button that is located in the lower right corner of the homepage. Pressing this

button opens up a navigation screen that gives the possibility to open up the possibility to add/modify or delete currency info.

By pressing the 'Add Currency' button in the navigation screen you open up an input pop-up screen. In this screen you can enter a currency name, the corresponding symbol and the rate of the currency in comparison to the companies preferred currency. Press the confirm button on the bottom of the pop-up screen to save the entered details to the database.

By pressing the 'Modify/Delete Currency' button in the navigation screen you open up a pop-up screen. This pop-up screen has a selection section on the right, which shows all currencies that are already entered into the system. Select a currency from this selection section that you want to modify or delete. After that press the delete button in the lower right corner of the pop-up screen to delete this currency out of the database. If you want to change certain details of the currency you can do that by changing this in the right textboxes after selection the corresponding currency on the left. To confirm the changes you have to press the change button at the bottom of the pop-up screen.

Appendix D.c Projects

Projects need to be selected before the material list, orders and financials can be viewed and used of the concerning project. All these features will be discussed in later chapters. Projects can be created, modified and selected by pressing the 'Project Selection' button that is located on the left of the homepage. Pressing this button will open a pop up screen with two buttons as can be seen in figure 40 that can be found below.



Figure 40: Project selection

In this pop-up screen will pressing the 'Select Project' button lead you to an overview screen at which you can see all projects that are already created and saved in the database. In this screen you can modify already created projects. In this way you can update the status of your projects or modify/add information to the project. From the overview screen it is also possible to select created projects. This will make it possible to edit and view the material list, orders and all financials of the project. In the pop-up screen that is also visible in figure 41, will pressing the 'Create Project' button, just as pressing the 'New Project' button in the initial pop-up screen lead you to a form page at which you can enter a new project with all details of the project. The form page has 4 control buttons at the top of the screen and below that a form in which the user can add all details of the project.

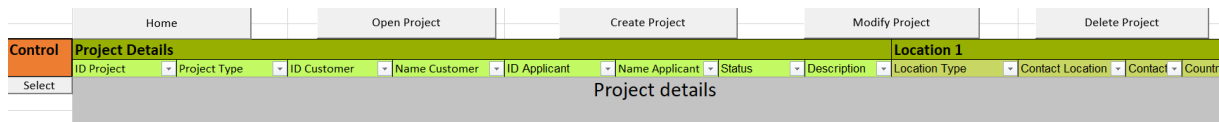


Figure 41: Project overview

Appendix D.d Material list

The material list is a list with the complete exposition of the project. The material list contains: The materials, the properties of the concerned material, manufacturer info, supplier info, order info, budget planning and other financials. The material list can be accessed from the homepage by pressing the 'Material List' button that is located on the left of the homepage.

The material list is built up out of an overarching header control area and a list area with corresponding controls integrated. The overarching header control area gives the user the power to influence or use the overall material list. It gives options to autofill missing elements of the material list, save the material list and create different order types. The list area gives the user the control to enter all materials that are required/needed in a project. All these materials can be added in different sections and subsections to create a clear breakdown of where in the system specific materials are required/needed. A breakdown of how the material list is build up can be found in figure 42, which can be found below.

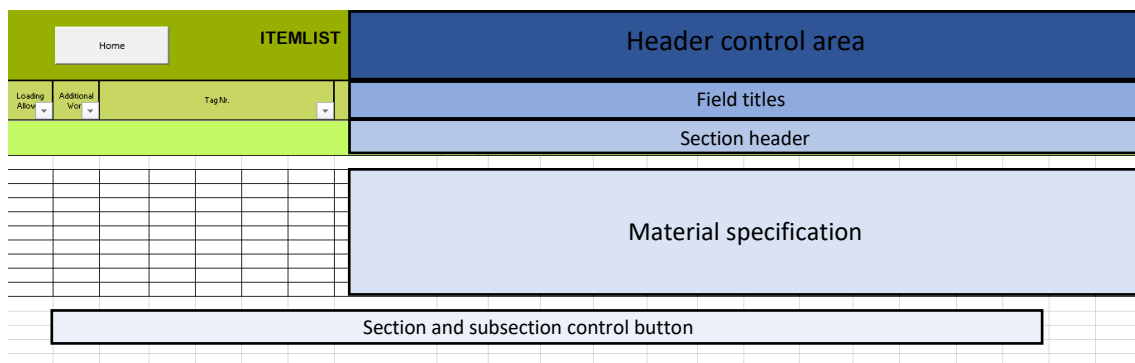


Figure 42: Material list overview

The header control area possesses multiple features that can be accessed with different buttons, the use and names of these buttons can be found below.

- The first feature is loading missing item details, which can be accessed by pressing the 'Load all items' button. With this feature the application can automatically add missing material details of a row of your material list. This is done by using the currently added details and searching in the database for a matching material. Missing details of this material will then be added to your material list. This can only be used for rows where only one result out of the database matches the details out of the material list. Another functionality of this feature is that it can help in selecting an appropriate manufacturer. It will select a supplier that matches already used suppliers as much as possible and will look for the lowest price. The first field title

with the name 'Loading Allowed' can be used to disable this function for certain rows. This can be used to prevent the application from changing the user's inputs. This can be useful when conditions apply that the program is not aware of or if materials are entered in the material list that are not implemented in the database.

- The second feature is saving the material list, which can be accessed by pressing the 'Save Material List' button. This feature will save the created material list to the database. The application will not save the material application automatically, so it is very important to save the material list when switching projects or closing down the application.

The other features are used for creating different types of order papers. This will be explained more in detail in appendix D.e, but a quick rundown of these features can also be found below.

- The third feature is creating a purchase order. This feature will automatically create a purchase order out of the by the user selected materials.
- The fourth feature is creating a confirmation of order. This feature will automatically create a confirmation of order out of the by the user selected materials.
- The fifth feature is creating a receipt. This feature will automatically create a receipt out of the by the user selected materials.
- The sixth feature is creating a packing slip. This feature will automatically create a packing slip out of the by the user selected materials.

The field titles serve as headers of the respected column. The names and functions of all field titles can be found below.

Loading allowed	-	This column can be used to disable the use of the loading missing item details feature.
Additional work	-	Indicates whether or not the material was part of the initial planning/project.
Tag number	-	The tag number consist of five different columns. All five columns can be used to give a specific number to the material which should be linked to the location of the material in the overall project.
System description	-	Give a short description of how the material is linked and used in the overall system.
Supplier	-	This column indicates who is the supplier of the material to the client/project owner.
Manufacturer	-	This column indicates who is the manufacturer of the material.
Object number	-	The unique number of the material, this number is given by the user.
Composition/part	-	This column indicates if the material consists of only a single part or if it is a combination of different parts.

Object description	-	Gives a short description of the material.
Quantity	-	How many of this certain part a needed.
Manufacturer article number	-	This column indicates the unique number of the material that was given by the manufacturer.
Drive mechanism	-	The type of mechanism the material uses to operate.
Control instrument	-	The type of control instrument that is used in the material.
Type actuator	-	What for actuation method the material uses.
Operating pressure	-	What pressure level is reached when using the material.
Connection	-	The type of connection that is used by the material.
Dimension DN	-	The term diameter nominal refers to the internal diameter of a pipe.
Length	-	Gives the length of the material.
PN	-	The term piconewton is a measurement of force. This indicates under what amount of force the material can still operate.
Material	-	The type of material of which the material consists.
Seal	-	The type of seal that is used by the material
Measuring range	-	It gives the range of measurements in which defined or guaranteed error limits are not exceeded.
RPM	-	Stands for Revolutions per minute, it indicates the number of turns the material does in one minute.
Power kW	-	The amount of energy that the material uses, indicated in kilowatt hour.
Hz	-	The frequency at which the material operates, indicated in hertz
Digital input	-	The amount of digital inputs that are present on the material.
Digital output	-	The amount of digital outputs that are present on the material.
Analog input	-	The amount of analog inputs that are present on the material.
Analog output	-	The amount of analog outputs that are present on the material.
E-power supply	-	The amount of electrical power the component requires.
Signal	-	What type of signal is used by the material.
Type	-	What for type of component it is.
Temperature	-	In which temperatures the component can operate safely.
EHEDG certificate	-	Specifies if the material has a EHEDG certification, which is a certification for the hygienically design of the material.
ATEX zoning	-	Specifies if the material has a ATEX zonering/certificate

		and which type of ATEX zoning the material possesses. This certificate indicates the explosion safety of the material.
Comment	-	Extra field to add more information or details.
Purchase order number	-	A unique number that is used to create purchase orders with different materials out of the material list.
Order date	-	The date of when the material was ordered from the Supplier.
Delivery date	-	The date of when the material should arrive.
Date of receipt	-	The actual date of when the material arrived.
Purchase list price	-	The listing price for the material, when purchasing the material from the supplier.
Purchase discount	-	The discount that is given on the material. This discount is deducted from the purchase list price.
Purchase net unit price	-	The final price that is reached when deducting the purchase discount from the purchase list price.
Purchase confirmation of order number	-	This number is used to record confirmation of order numbers from suppliers to make them easily retraceable.
Purchase receipt number	-	This number is used to record receipts numbers from suppliers to make them better retraceable.
Purchase packing slip number	-	This number is used to record packing slip numbers from suppliers to make them better retraceable.
Sale purchase order number	-	This number is used to record purchase order numbers from clients to make them better retraceable.
Confirmation of order number	-	A unique number that is used to create confirmation of orders with different materials out of the material list.
List price	-	The listing price of the material by the users company.
Discount	-	The standard discount that is given on the material. This will be deducted from the list price.
Net unit price	-	The price that is reached when deducting the discount from the list price.
Extra discount	-	An extra discount that may be given on a material. This extra discount is added to the discount value mentioned before.
Final net unit price	-	The price that is reached when deducting both the discount and extra discount from the list price.
Receipt number	-	A unique number that is used to receipts with different materials out of the material list.
Packing slip number	-	A unique number that is used to packing slips for different materials out of the material list.

Budget calculation	-	This value implies the budget that has been made available for the purchase of the relevant material.
Total purchase price	-	This value implies the actual total purchasing costs that have been made in the purchase of the relevant material.
Total sale price	-	This value implies the actual sale price that has been paid for the material by the client.
Invoice already delivered	-	This value implies the amount of money that has already been paid by the client for the purchase of the relevant material.
Incoming invoice	-	This value implies the amount of money that still has to be paid by the client for the purchase of the relevant material.
Total realized costs	-	This value implies the actual total costs that have been made in the purchasing process of the material. This price can differ from the total purchase price through potential delivery, processing or extra manufacturing costs.
Deviation from budget	-	This value implies the difference between the budget that was set up for the purchasing of the relevant material and the actual total realized costs.

Next to the header control area and the field titles serve the section header, material specification and section and subsection control button area together for the ordering and creation of the material list itself. The section and subsection control buttons are the basic controls to create the material list. These controls consist of 6 different control buttons. The basic controls are the 'New Row' and 'Delete Row' buttons with which the user can add or delete a row to the material list. In such a new row can a new material be entered by the row. The other 4 control buttons are 'New Subsection', 'Delete Subsection', 'New Section' and 'Delete Section'. All 4 control buttons are used to create different sections within the material list. These sections can be used to distinguish different stages of the overall project. This makes it for example possible to differentiate two different machines from each other. Below in figure 43, 44, 45 can be found examples of how all the different 6 control buttons work.



Figure 43: Functionality new row and delete row buttons

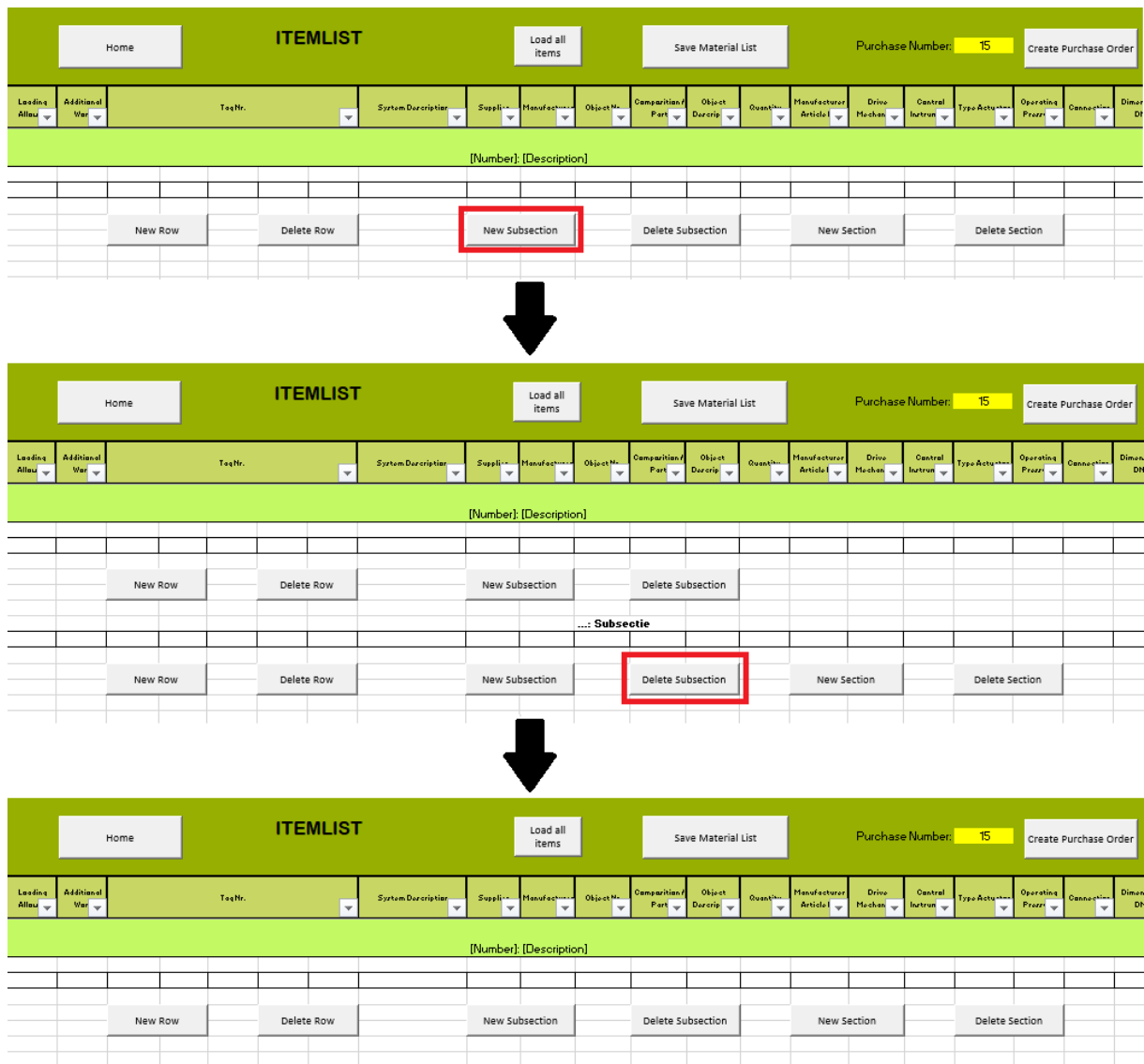


Figure 44: Functionality new subsection and delete subsection



Figure 45: Functionality new section and delete section

Appendix D.e Orders

Different types of order papers can be created within the material list. A more elaborate explanation of the complete material list can be found in appendix D.d. This section will focus on only the order paper creation that can be done within the material list.

There are 4 different types of order papers that can be created within the application. Below can be found a quick overview of the function of all 4 order papers.

- Purchase order - Is a document and first official offer issued by the user as buyer to a seller indicating types, quantities, and agreed prices for products or services.
- Confirmation of order - Is a written confirmation of an order which is sent by the producing or service rendering company that accepts the order

		placed by the user as purchasing customer. It serves as a tool to avoid confusion and mistakes in case the order does not conform to the original offer.
Receipt	-	This document acknowledges that a receivment of money in payment following a sale of goods or services has been made.
Packing Slip	-	Is a list of what is included in a shipment.

Starting with the purchase order, this order list will be built with the data out of the columns: Manufacturer, manufacturer article nr., object description, quantity, purchase list price, purchase discount, purchase net unit price and purchase order number.

Creating a purchase order is done in the following way. The user has entered materials into the material list that are needed for a project. These materials should contain data about all data columns specified above, only if you are sure that the info isn't needed can certain data fields be left blank. All materials that the user wishes to order in the same transaction should be indicated with a matching number in the purchase order number column. This number should be a unique number because it is also used as purchase order number on the document and this makes purchase orders retraceable. Now enter the same number into the yellow purchase number entry box, located next to the 'Create Purchase Order' button in the header control area of the material list. If now the 'Create Purchase Order' button is pressed will a new sheet be opened with the matching materials data inserted. All details can still be changed and even new entries can be added to the purchase order as long as the shape of the purchase order is not altered. The purchase order sheet also offers two different list boxes to help the user edit the purchase order. The first list box can be found in the right upper corner with the name 'Contact'. This shows all contacts that are associated with the manufacturer from which the materials are ordered. The selected contact will automatically be represented on the purchase order. The second list box can be found below the first list box and has the name 'Colleague'. This shows all colleagues that are associated with the company of the user. The selected colleague will automatically be represented on the purchase order. The purchase order sheet offers 4 control buttons to save and finalize the purchase order and to navigate to another sheet in the application. The button 'Create PDF' will open a save as pop-up box that gives the user the ability to save the purchase order anywhere they want. The button 'Confirm Purchase Order' will make the background of the associated cells in the material list of the purchase order number column green. This gives the user a clear indication in the material list at which state of the ordering process certain materials are. The button 'Home' and 'Material List' are used to navigate to their respective location. An overview of how the purchase order is build up can be found below in figure 46.



Boelsma Projectmanagement & Engineering B.V.

Contact info
manufacturer/supplier

Order characteristics

Hierbij doen wij onze inkoopopdracht toekomen voor levering van:

Pos	Artikel Nummer	Beschrijving	Aantal	Stukprijs	Korting	TOTAAL Netto
Automatically created counter	Article number taken from the material list	Object description taken from the material list	Quantity taken from the material list	Purchase list price taken from the material list	Purchase discount taken from the material list	Purchase net unit price taken from the material list

Supply conditions

Automatically
calculated total
pricing

Hoogachtend,
Boelsma Projectmanagement en Engineering B.V.

Employee details

Figure 46: Purchase order overview

the confirmation of order will be built with the data out of the columns: object nr., object description, quantity, list price, discount, net unit price and confirmation of order number. Next to the columns from the material list is also the currently active client info used. This is the case because materials will most of the times be forwarded to the project client. If this is not the case than need these details be changed by hand.

Creating a confirmation of order is done in the following way. The user has entered materials into the material list that are needed for a project. These materials should contain data about all data columns specified above, only if you are sure that the info isn't needed can certain data fields be left blank. All materials that the user wishes to order in the same transaction should be indicated with a matching number in the confirmation of order number column. This number should be a unique number because it is also used as confirmation of order number on the document and this makes confirmation of orders retraceable. Now enter the same number into the yellow confirmation of order entry box, located next to the 'Create Confirmation Of Order' button in the header control area of the material list. If now the 'Create Confirmation Of Order' button is pressed will a new sheet be opened with the matching materials data inserted. All details can still be changed and even new entries can be added to the confirmation of order as long as the shape of the confirmation of order is not altered. The confirmation of order sheet also offers two different list boxes to help the user edit the purchase order. The first list box can be found in the right upper corner with the name 'Contact'. This shows all contacts that are associated with the project client. The selected contact will automatically be represented on the confirmation of order. The second list box can be found below the first list box and has the name 'Colleague'. This shows all colleagues that are associated with the company of the user. The selected colleague will automatically be represented on the confirmation of order. The confirmation of order sheet offers 4 control buttons to save and finalize the confirmation of order and to navigate to another sheet in the application. The button 'Create PDF' will open a save as pop-up box that gives the user the ability to save the confirmation of order anywhere they want. The button 'Confirm Confirmation Of Order' will make the background of the associated cells in the material list of the confirmation of order number column green. This gives the user a clear indication in the material list at which state of the ordering process certain materials are. The button 'Home' and 'Material List' are used to navigate to their respective location. An overview of how the confirmation of order is build up can be found below in figure 47.



Boelsma Projectmanagement & Engineering B.V.

Contact info project client

Order characteristics

Wij danken u voor uw gewaardeerde opdracht en bevestigen u hierbij.

Pos	Artikel Nummer	Beschrijving	Aantal	Stukprijs	Korting	TOTAAL Netto
Automatically created counter	Article number taken from the material list	Object description taken from the material list	Quantity taken from the material list	List price taken from the material list	Discount taken from the material list	Net unit price taken from the material list

Supply conditions

Automatically
calculated total
pricing

Hoogachtend,
Boelsma Projectmanagement en Engineering B.V.

Employee details

Figure 47: Confirmation of order overview

The Receipt will be built with the data out of the columns: object nr., object description, quantity, list price, discount, net unit price and receipt number. Next to the columns from the material list is also the currently active client info used. This is the case because materials will most of the times be forwarded to the project client. If this is not the case than need these details be changed by hand.

Creating a receipt is done in the following way. The user has entered materials into the material list that are needed for a project. These materials should contain data about all data columns specified above, only if you are sure that the info isn't needed can certain data fields be left blank. All materials that the user wishes to group in the same transaction should be indicated with a matching number in the receipt number column. This number should be a unique number because it is also used as receipt number on the document and this makes receipts retraceable. Now enter the same number into the yellow receipt entry box, located next to the 'Create Receipt' button in the header control area of the material list. If now the 'Create Receipt' button is pressed will a new sheet be opened with the matching materials data inserted. All details can still be changed and even new entries can be added to the receipt as long as the shape of the receipt is not altered. The receipt sheet also offers two different list boxes to help the user edit the receipt. The first list box can be found in the right upper corner with the name 'Contact'. This shows all contacts that are associated with the project client. The selected contact will automatically be represented on the receipt. The second list box can be found below the first list box and has the name 'Colleague'. This shows all colleagues that are associated with the company of the user. The selected colleague will automatically be represented on the receipt. The receipt sheet offers 4 control buttons to save and finalize the receipt and to navigate to another sheet in the application. The button 'Create PDF' will open a save as pop-up box that gives the user the ability to save the receipt anywhere they want. The button 'Confirm Receipt' will make the background of the associated cells in the material list of the receipt column green. This gives the user a clear indication in the material list at which state of the ordering process certain materials are. The button 'Home' and 'Material List' are used to navigate to their respective location. An overview of how the receipt is build up can be found below in figure 48.

Relatie:

Contact info project client

Order characteristics

Aantal	Omschrijving	Prijs	Btw	Bedrag
Quantity taken from the material list	Article number and object description combined and taken from the material list	Price calculated with use of the material list	Standard VAT of 21 percent	Automatically calculated total price
				Automatically calculated total pricing

Company details

Figure 48: Receipt overview

The packing slip will be built with the data out of the columns: object nr., object description and quantity. Next to the columns from the material list is also the currently active client info used. This is the case because materials will most of the times be forwarded to the project client. If this is not the case than need these details be changed by hand.

Creating a packing slip is done in the following way. The user has entered materials into the material list that are needed for a project. These materials should contain data about all data columns specified above, only if you are sure that the info isn't needed can certain data fields be left blank. All materials that the user wishes to group in the same transaction should be indicated with a matching number in the packing slip number column. This number should be a unique number because it is also used as packing slip number on the document and this makes packing slips retraceable. Now enter the same number into the yellow receipt entry box, located next to the 'Create Packing Slip' button in the header control area of the material list. If now the 'Create Packing Slip' button is pressed will a new sheet be opened with the matching materials data inserted. All details can still be changed and even new entries can be added to the packing slip as long as the shape of the packing slip is not altered. The packing slip sheet also offers a list box to help the user edit the packing slip. The list box can be found in the right upper corner with the name 'Contact'. This shows all contacts that are associated with the project client. The selected contact will automatically be represented on the packing slip. The packing slip sheet also offers 4 control buttons to save and finalize the packing slip and to navigate to another sheet in the application. The button 'Create PDF' will open a save as pop-up box that gives the user the ability to save the packing slip anywhere they want. The button 'Confirm Packing Slip' will make the background of the associated cells in the material list of the packing slip column green. This gives the user a clear indication in the material list at which state of the ordering process certain materials are. The button 'Home' and 'Material List' are used to navigate to their respective location. An overview of how the packing slip is build up can be found below in figure 49.



Boelsma Projectmanagement & Engineering B.V.

Relatie

Contact info project client

Order characteristics

Pos	Beschrijving	Aantal Besteld	Aantal Geleverd	Nog te leveren
Automatically created counter	Article number and object description combined and taken from the material list	Quantity taken from the material list	Left empty, must be defined by user	Automatically calculated number of materials that still need to be delivered

Company details

Figure 49: Packing slip overview

Appendix D.f Financials

A complete overview of the financials of the currently selected project can be found by pressing the 'Financials Selected Project' button that is located on the right of the homepage. Pressing this button opens up a new page with all financial data. This data is a summary of the financials out of the material list. It shows the budget calculations but also the actual costs that were made. This is done by giving the financial status of every stage that was created in the material list and also the financial status of the complete project. This should provide the user with the necessary info about how the project is doing and in which areas unexpected costs or profits have occurred. For an overview about how the financials page is set up please have a look at figure 50, that can be found below.

Home	SAMENVATTING PROJECTKOSTEN							Customer: Project: Projectnumber: Status Project:	Information about the project								
Go back to the homepage.	Section:	Budget Calculation	Total Purchase Price	Invoice Already Received	Incoming Invoice	Total Realized Costs	Deviation From Budget	Meerwerk			k/w	Di	Do	Al	Ao		Projectresult
	Financial results of every section																Financial status of the complete project

Figure 50: Financial overview

Appendix E: Technology Acceptance Questionnaire

Name: Alvin Boelma
 Function: DGA

1. I find the system easy to use.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	Totally agree

2. I see myself actually using the system.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	Totally agree

3. The way in which I have to use the system is clear.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	Totally agree

4. The system possesses features that can really speed up the work process.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Totally agree

5. The system should make it possible to take on more projects in the same timeframe.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	Totally agree

6. The system makes the workflow of the company more efficient.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	Totally agree

7. I would like the continuation of the development of this or a similar platform.

	1	2	3	4	5	6	7	
Totally disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Totally agree

Figure 51: Technology Acceptance Questionnaire