



# UNIVERSITY OF TWENTE.

Faculty of Electrical Engineering,  
Mathematics & Computer Science

## Multi-Criteria and Model-Based Analysis for Project Selection

An Integration of Capability-Based Planning  
and Project Portfolio Management

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# MASTER THESIS

## **Multi-Criteria and Model-Based Analysis for Project Selection**

*An Integration of Capability-Based Planning and Project Portfolio Management*

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## Management Summary

Nowadays, organizations are faced with so many investment decisions. These investment decisions are mostly related to which projects the organization must undertake in order to achieve their goals. This might be due to the fact that projects are considered as the key instrument to deliver organizational strategies. However, these projects are often influenced by several drivers, such as competitive demand, specific concerns of the stakeholders, availability of resources, and varying levels of risk. Thus, organizations often encounter some difficulties when making investment decisions.

Based on this, the following problems are highlighted in this master thesis. First, there is a need for a method that could help organizations in solving investment decisions. We address this issue in the thesis by integrating the concept of project portfolio management and capability based planning with analytical tools for assessment. Thus, in order to be able to select the most efficient investment, we propose that combining the assessment of projects and capabilities as selection criteria could help the organization when facing investment problem. In addition, there is only limited research on how to integrate the concept of project portfolio management and capability based planning. We propose that the integration of both project and capability assessment is needed in order to select the most efficient decision in a project selection.

This master thesis provides a guidance of project selection process for organizations. It is expected to help organizations to select the best investment by using the proposed method which incorporates a combination of capability assessment, project assessment, analytical tools, and EA-based analysis.

### **Objective:**

The goal of this research is to develop an analysis method that integrates the concept of capability based planning and project portfolio management. This method should be able to help an organization with their investment decisions through a comprehensive project selection process based on capabilities, which is expected to help organizations to manage their capabilities. Moreover, the purpose of this research is also to incorporate analytical techniques that can be used for assessing both of the related concepts.

### **Methodology:**

This research can be categorized as a design science problems based on the definition by Wieringa (2014), since the purpose of this research is to solve a specific problem (investment decision problem) by designing an artifact (the proposed method in Chapter 3). Therefore, as a design science research, this thesis will follow Design Science Research Methodology (DSRM) proposed by Peffers et al. (2007) to structure the chapters of this master thesis report.

### **Key Findings:**

The proposed method provided as a result of this research is expected to help organizations with making decisions regarding investments based on capabilities and multiple selection

criteria. The proposed method consists of eight steps that can be performed in parallel. In addition, several techniques are incorporated in the method in order to support the analysis required. This includes a combination of multi-criteria decision-making methods, enterprise-architecture-based modelling, and mathematical programming model. To conclude, some key findings from each chapter in this report is presented as follows:

- o Chapter 2 provides answers regarding questions relating to the state of the art developments for CBP and PPM concepts, along with available analysis techniques for both related concepts. It is found that there are still not many available assessment techniques for capabilities. Moreover, comprehensive research about the integration and connection between CBP and PPM is also still lacking in the literature. The main key findings in this part are the analysis methods that are chosen for the development of the proposed method.
- o Chapter 3 explains the development process of the proposed method. The key outcome of this chapter is the proposed method itself, along with detail steps and activities that must be done in the proposed method.
- o Chapter 4 describes the demonstration of the proposed method. In this chapter, a case study of an energy power supplier company is provided. It shows that the proposed method is also applicable to the energy industry if the practice of capability-based planning management and project management are in place. In addition, it also indicates that the method requires extensive data, especially in the final project selection analysis, since all the data of the proposed projects must be present for the analysis to be possible.
- o In Chapter 5, the evaluation phase of the proposed method is described, along with the result of the evaluation workshop. It shows that for the majority of the aspects, the participants in the evaluation workshop gave positive feedback regarding the proposed method. Moreover, the result shows the most positive feedback for self-efficacy aspect, which means that the participants are willing to use the proposed method, especially if they can get help when facing any difficulties in using the method.
- o Chapter 6 concludes this master thesis report followed by contributions for both theory and practice, limitations, and possible future work. One of the limitation is this research uses a trial version of third-party software for the calculation of DEA model, which results in the possibility of having more than one project as the most efficient one. Thus, one of the future work discussed is to apply other quantitative models for the analysis as part of the method.

## Acknowledgment

This master thesis report marks the completion of my master study in the Netherlands. The overall journey on pursuing a master degree truly has been an amazing experience for me. I am incredibly grateful for this opportunity, and I can conclude that the knowledge I gained during this period has enhanced my academic, career, and personal development. Of course, this would not be possible without the support, help, guidance, and prayers of the people surrounding me.

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I would like to close by thanking everyone that has been part of this journey. I wish you good luck with everything and I hope that we will meet again someday.

Enschede, August 2017

Latifah Helmy Masyhur

## About BiZZdesign

BiZZdesign is a global market-leading Enterprise Architecture software organization that provides an advanced platform for planning, tracking and executing business change headquartered in the Netherlands. Besides software provider, BiZZdesign also offers consultancy services in various fields such as Business Model Management, Enterprise Architecture Management, and Business Process Management. It is founded in 2001 by Henry Franken, Harmen van den Berg and Harm Bakker as part of a spin-off from an applied R&D institute, which is why the organization has strong roots in research and innovation.

BiZZdesign is known for the co-development of ArchiMate and the development of BiZZdesign Enterprise Studio, the first tools that supported ArchiMate® 3.0. BiZZdesign Enterprise Studio is a collaborative business design platform that offers powerful, integrated modelling across multiple disciplines. Enterprise Studio is the first platform to support modelling in the new ArchiMate® 3.0, the open standard language for enterprise architecture modelling. During the research, Enterprise Studio tool was very helpful and very applicable to be used for the method proposed in this research. Besides for enterprise architecture modelling, this tool also supports the analysis performed as part of the method, such as risk analysis. In addition, the metrics functionality in Enterprise Studio could also aids in the quantification and visualization of the analysis result, which is considered very valuable for this research.

Every semester BiZZdesign offers the opportunity for master students to do their graduation project in the company. The topics for the graduation project that BiZZdesign provides vary from Enterprise Architecture, Portfolio Management, Capability Based Planning, Business Process Management, and Strategic Planning. BiZZdesign also works closely with the universities, research institutions, their clients and partners on improving existing tools and developing new tools and methods in the industry.

BiZZdesign is an active member of several consortia such as The Open Group, ArchiMate Forum, BPM Forum, and National Architecture Forum. Moreover, since BiZZdesign experts are closely involved in the development of the ArchiMate language, BiZZdesign is also the first officially accredited company worldwide to provide ArchiMate® 3.0 training<sup>1</sup>. Besides ArchiMate, BiZZdesign also offers a range of interactive training courses on software and methodology, such as TOGAF, BPMN, and Business Architecture Certified courses. These courses are mainly designed for enterprise architects, business architects and process managers alike.

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<sup>1</sup> <http://www.bizzdesign.com/news-pr/bizzdesign-first-accredited-provider-archimater-30-training-courses-worldwide>

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## List of Abbreviations

<b>AHP</b>	Analytic Hierarchy Process
<b>APQC</b>	American Productivity and Quality Center
<b>BAL</b>	Balancing
<b>BC</b>	Best Case
<b>BPMN</b>	Business Process Model and Notation
<b>BSC</b>	Balanced Scorecard
<b>CBAM</b>	Cost Benefit Analysis Method
<b>CBP</b>	Capability Based Planning
<b>CMM</b>	Capability Maturity Model
<b>CRM</b>	Customer Relationship Management
<b>DC</b>	Decision Criteria
<b>DEA</b>	Data Envelopment Analysis
<b>DMU</b>	Decision Making Units
<b>DSRM</b>	Design Science Research Methodology
<b>EA</b>	Enterprise Architecture
<b>EPM</b>	Enterprise Portfolio Management
<b>EPS</b>	European Power Supplier
<b>ICT</b>	Information and Communication Technology
<b>IRR</b>	Internal Rate of Return
<b>LEF</b>	Loss Event Frequency
<b>LP</b>	Linear Programming
<b>MAUT</b>	Multi-Attribute Utility Theory
<b>MCDA</b>	Multi-Criteria Decision Analysis
<b>MPT</b>	Modern Portfolio Theory
<b>NPV</b>	Net Present Value
<b>PLM</b>	Probable Loss Magnitude
<b>PMBOK</b>	Project Management Body of Knowledge
<b>PMI</b>	Project Management Institute
<b>PP</b>	Payback Period
<b>PPM</b>	Project Portfolio Management
<b>RA</b>	Resource Allocation
<b>RAI</b>	Return on Average Investment
<b>RBA</b>	Risk Benefit Analysis
<b>ROI</b>	Return on Investment
<b>SAM</b>	Strategic Alignment Model
<b>SEI</b>	Software Engineering Institute
<b>SLR</b>	Systematic Literature Review

<b>SM</b>	Strategic Management
<b>SPOS</b>	Selection, Prioritization, Optimization, and Sequencing
<b>STDEV</b>	Standard Deviation
<b>TOGAF</b>	The Open Group Architecture Framework
<b>UML</b>	Unified Modelling Language
<b>UTAUT</b>	Unified Theory of Acceptance and Use of Technology
<b>WC</b>	Worst Case

# 1 Introduction

Nowadays, organizations are faced with so many investment decisions. These investment decisions are mostly related to which projects the organization must undertake in order to achieve their goals. This might be due to the fact that projects are considered as the key instrument to deliver organizational strategies. However, these projects are often influenced by several drivers, such as competitive demand, specific concerns of the stakeholders, availability of resources, and varying levels of risk. Thus, organizations often encounter some difficulties when making investment decisions.

Generally, the role of Project Portfolio Management (PPM) is to evaluate, select, and prioritize new projects, as well as to revise priority, and possibly eliminate and reduce projects in progress (Danesh et al., 2015). In addition, Padovani and Carvalho (2016) also stated in their paper that PPM is an emerging aspect of business management that focuses on how projects are selected, prioritized, integrated, managed and controlled in the multi-project context that exists in modern organizations. This means that PPM mainly deals with the activities in investment decisions as part of project portfolio selection, which is why it will be the main focus of this research. It is also important to note that PPM not only deals with investment decisions, but also consists of various ranging elements to support the overall cycle of the portfolio management, e.g. portfolio optimization, portfolio approval, and portfolio evaluation.

By definition, project portfolio selection is the periodic activity involved in selecting a portfolio of projects, that meets an organization's stated objectives without exceeding available resources or violating other constraints (Ghasemzadeh & Archer, 2000). Even though project portfolio selection is a crucial decision in many organizations, it is not an easy task as it often involves multiple and various selection criteria, which might vary based on the needs of the organizations. The important criteria for project selection are mainly discussed in the area of project portfolio management discipline, which include the expected cost, associated risk, and benefit of the investments.

However, in addition to PPM, the concept of capability-based planning (CBP) can be used to complement the decision-making process in project selection. Capabilities can provide a foundation for assessing and prioritizing strategic mission, and linking motivation with operational activities (Scott, 2014). Thus, it could serve as one of the criteria when choosing the best investment decision. Moreover, CBP can be used as the business-oriented starting point for any discussion around strategic planning and can help to determine the impacts of those plan from an enterprise perspective (Ulrich & Rosen, 2011). This implies that knowing what are the impacts of the investment on capabilities is crucial for project or investment decisions in order to make sure the investment will help to realize specific goals of the organizations.

Under this consideration, organizations need to reflect their capabilities or the result of capabilities assessment in the criteria for selection of investment project portfolio, in addition to other important criteria. This could help an organization to choose the best investment based on their strategic needs, and to make sure that the selected investment will address



the specific goals derived from specific motivation or driver. Since several criteria are involved in solving the investment decision problems, analytical techniques that could help to solve the complexity due to multiple criteria must be adopted.

In order to develop a project selection method that could help organizations in solving investment decisions, the assessment of both capabilities and projects will be integrated along with the adoption of some analytical tools to perform the assessment. Consequently, the main objective of this research is to design a practical method for project selection that integrates the concept of PPM and CBP, focusing on the assessment of each concept. The proposed method in this research should be able to help organizations in determining which investments decisions should be made based on the presence of multiple important criteria.

The purpose of this chapter is to describe the background information and motivation of conducting the research. Section 1.1 provides an overview of the problem statement that motivates the research, which is followed by the research objective in Section 1.2. Subsequently, the research questions are formulated in Section 1.3 as the structural basis to conduct the research. Afterwards, the research methodology chosen to be carried out in the research is elaborated in Section 1.4. To conclude, the structure of the thesis report is provided in the last section.

## 1.1 Problem Statement

As explained earlier, the presence of various criteria when selecting an investment makes it even more challenging to agree on an investment decision. The activities in solving investment decision problems are usually included as part of the concept of Project Portfolio Management (PPM). In the literature, Project Portfolio Management (PPM) is argued to enable organizations to achieve strategic alignment (Kaiser et al., 2015; Meskendahl, 2010). Moreover, various authors sustain that project portfolio management plays an important role, since it is contributing to enable companies to continuously gain competitive advantages (Kaiser et al., 2015; Padovani & Carvalho, 2016). The employment of PPM in organizations can lead to an improvement in strategy implementation and project delivery success rates, or in other words, bridging the gap between strategy development and strategy implementation (Buys & Stander, 2010).

Going back to investment decision problems, one of the important criteria that must be considered is the impact on these investments on organizations' capabilities, since capabilities are defined as what the organizations are capable of doing in order to achieve their strategic objectives. Based on the literature, the concept of Capability-Based Planning (CBP) can be used for aligning capabilities with strategy (TTCP, 2004). This could support the argument that the assessment of capabilities which is part of the CBP method must be considered as one of the criteria when selecting investment decisions. Moreover, Aldea, A. I. (2017) in her dissertation also mentioned that the concept of CBP and PPM could be linked to each other, along with the concept of Enterprise Architecture and Strategic Management.

There are several studies available in the literature that focus on the method to perform CBP in practice (Aldea, 2017; Cheng, 2015; Papazoglou, 2014). Papazoglou (2014), for example,

refined the original CBP process model and presented the main steps on how to use the CBP method. However, there is still only a few studies that combine the concept of CBP with any project or investment selection methods.

In summary, both PPM and CBP concepts play an important role in solving investment decision problems, since both disciplines could provide the necessary criteria in order for organizations to select the best project for a specific goal or problem. In addition to that, both of these concepts have also been identified as solutions to improve strategic alignment in organizations, along with another concept such as Enterprise Architecture (Aldea et al., 2015; Amaral & Araújo, 2009; Rosselet & Wentland, 2011).

However, there are not many types of research that can be used in practice so far that integrates the concept of CBP and PPM. Wang, Y. (2016) in her research presented a method that used the CBP to describe how the ongoing projects contribute to the organization by identifying the objectives of the projects and mapping the goals to the high-level capabilities. However, in her research, CBP is used to assess the ongoing projects, and not during the phase of project selection.

It is also argued in the literature that projects are seen as a way to realize capability increment, this means the ongoing projects are supposed to enable capability improvement. Yet, there is no clear guideline how exactly this increment could be realized if capability analysis is not incorporated in the project portfolio management processes, especially during project selection phase.

Hence, the purpose of this research is to help organizations to integrate the concept of capability based planning and project portfolio management for project selection, and also to provide an analysis based on these concepts. Based on the literature, it is argued that the input of the project portfolio selection should be also derived from capability assessment, and the output of the project portfolio process should contribute to the improvement of capability (capability increment). The proposed method in this research will focus on the former relationship between these two concepts.

## 1.2 Research Objective

The goal of this research is to develop an analysis method that integrates the concept of capability based planning and project portfolio management, which can help organizations to achieve their strategic objectives and achieve better strategic alignment. This approach should guide an organization through a comprehensive project selection process based on capabilities, which is expected to help organizations to manage their capabilities. Moreover, the purpose of this research is also to incorporate analytical techniques that can be used for assessing both of the related concepts.

To achieve the objective of the thesis, the following steps are proposed in order to design a project selection method based on capabilities:

- i. Conduct a literature review on different concepts, which is capability based planning and project portfolio management

- ii. Describe the process of linking capability with project selection process
- iii. Decide on relevant analytical techniques for capability and project assessment
- iv. Develop the multi-criteria and model-based project selection method
- v. Demonstrate how to apply the proposed method to a case study
- vi. Evaluate the conceptual model with a survey and a workshop
- vii. Discuss the limitations, further research, recommendation, and the overall result of the research

### 1.3 Research Questions

This subsection describes the list of research questions for this master thesis. The main research question will be explained in 1.3.1, and the sub research questions will be explained in Section 1.3.2.

#### 1.3.1 Main Research Question

Based on problem statement and the objectives of the thesis, the main research question is formulated as follows:

***“How to develop an analysis method that integrates the concept of capability-based planning and project portfolio management?”***

#### 1.3.2 Sub Research Questions

The following sub-questions are formulated to assist in answering the main research question:

**1. *What is the state of art of Capability Based Planning (CBP) and Project Portfolio Management (PPM) in the literature?***

A literature study will be conducted in order to answer this research questions. Existing studies on both CBP and PPM concepts will be analyzed using a systematic literature review. The current state of the art of these concepts will be presented as a summary of the existing research.

**2. *What kind of analysis are available for CBP and PPM assessment?***

In order to answer RQ2, several steps are conducted during the study. First of all, various types of quantitative business analysis exist in the literature are gathered and reviewed. Secondly, a thorough study on whether these analyses is suitable to assess capabilities and projects is conducted. Based on this, the appropriate analysis techniques are chosen to be the basis of the analysis for this research.

After completing the steps as mentioned above, the relevant analysis will be used for the research include capability analysis and project analysis. Each of this includes several other analyses that will be explained in detail in Chapter 3.

**3. *How to develop an analysis method that integrates CBP and PPM?***

Several techniques and methods will be used to develop the analysis model. Firstly, the ArchiMate modelling language will be used to model all the analysis in the

approach. Some concepts in enterprise architecture and ArchiMate language such as the concept of risk, projects, capabilities, assessment, and metrics will be used for both capability and projects analysis. In addition, other analytical methods as a result of the second research questions will also be used as part of the analysis included in the approach.

#### 4. How to validate the proposed model?

In order to answer this research question, a case study of an energy power supplier company in Europe will be presented. The proposed approach will be applied to a case with the purpose to demonstrate how the approach can be applied to a real-world business case. In addition, the case study is expected to bring some improvements of the result, as it may help in removing the inefficiencies, as well as to identify possible opportunities by implementing the proposed approach. Furthermore, the proposed approach will be presented to real practitioners in the field to see whether the solution is feasible to be used in practice.

### 1.4 Research Methodology

Even though some of the research questions are knowledge questions, the main objective of the research is to design a method, which can be considered as a design problem. By definition, design problem calls for a change in the real world and require an analysis of actual or hypothetical stakeholder goals. A solution is a design, and there are usually many different solutions (Wieringa, 2014). Therefore, this research mainly uses the Design Science Research Methodology (DSRM) guidelines by Peffers et al. (2007). The DSRM Process Model is shown in Figure 1 below.

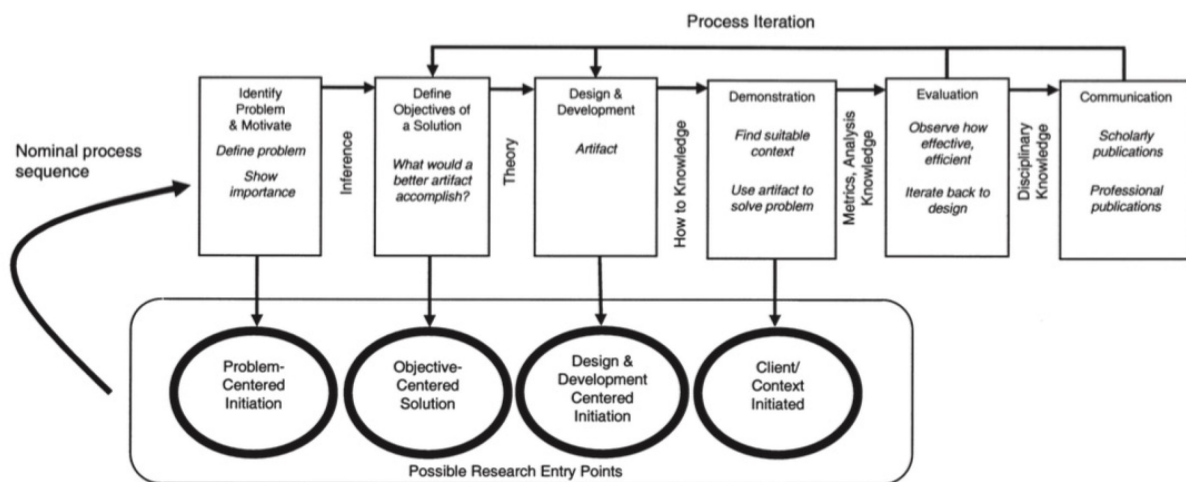


Figure 1 DSRM Process Model (Peffers et al., 2007)

Below is a brief description about how the research process is mapped into the DSRM Process Model steps and the distribution of this process within the report of the thesis:

- o Problem identification and motivation  
In this initial step, the identification of the problem is conducted and the solution of the problem is proposed in this. The motivation of the research and formulation of the

research questions is also performed here. The elaboration of this step is included in Chapter 1.

- o Define the objectives for a solution  
After defining the problem and the motivation behind this research, the next step is to define the objective of the solution that is proposed in the first step. The objective defined in this step is expected to provide a roadmap of the research and suggests a good way to proceed with, build upon prior literature in reference disciplines, and provide a template for a structure for research outputs. This step is included in Chapter 1 and 2.
- o Design and development  
The design and development step is described in Chapter 3. The process of defining each element of the solution is described in detail in this chapter. The process includes defining the input of each step in the method, defining the activities to be performed, the expected output, and the possible techniques that can be used for each step.
- o Demonstration  
The demonstration process is planned to be performed in a case study followed by the presentation of the result in a workshop. The visualization of the demonstration is presented in this step. This step is executed after the whole design and development process is already completed. This step is described in Chapter 4 and 5.
- o Evaluation  
The observation and measurement of the quality of the solution are conducted in this step. This step aims to compare the objectives of the solution to the result from the use of the proposed method, which includes a small workshop and survey to get the feedback. This part is described in Chapter 6.
- o Communication  
The last step of this research methodology is the communication step which will be done in the master thesis defense after the thesis have been finished and submitted.

## 1.5 Research Structure

As mentioned in the previous section, this research used DSRM as its research method. In structuring the research approach, this thesis follows the steps of DSRM. In general, this research can be divided into 5 parts: Literature Review, Design and Development, Demonstration, Evaluation, and Conclusion.

In the first part of the research, which is the literature review, the related research and the knowledge on the topic discussed in this thesis are gathered and explored. This part is also intended to answer some of the research questions, especially those related to state of the art in the literature. The main focus of this part is to present and discuss the underlying theories that might be useful in order to avoid any confusion about the topic.

The next part is the design and development, which can be considered as the main activity of the thesis. The knowledge gained from the literature review is used as the basis for the design and development part. It contains detail explanation of the chosen approach to develop the method. The high-level flowchart of the proposed method is also provided at the beginning

of this part. In addition, detail guideline on how to perform each step in the proposed method is also presented in the form of table.

The third part is the demonstration and visualization, which is similar to the testing part in software development. However, because it is difficult to perform a real test in a real organization, in this case the demonstration is conducted by using the case study of a European power supplier company, that is presented in the paper of Franke et al. (2010).

The next part of the thesis includes the evaluation of the proposed method based on the demonstration that has been completed during the demonstration. The evaluation is conducted using a survey that adapts the UTAUT concept by (Venkatesh et al., 2003). Prior to that, a small workshop is held, consisting of 5 participants. The participants of the workshop are expected to give feedback using the survey. Afterwards, the feedback is analyzed and the conclusion can be drawn. The limitation of the research and recommendation of future work are also described in the conclusion part.

In order to give a clear view on the highlight of each chapter, the summary of the structure of the thesis is shown in Table 1 below.

*Table 1 Research Structure*

Chapter	Activities	Research Questions
<b>1</b>	Introduction Problem identification, motivation, research goal, research objective and questions, and research methodology	
<b>2</b>	Literature Review Theoretical background of key concepts (CBP and PPM) and selection of the reference method.	RQ1 – RQ2
<b>3</b>	Design and model development Design of the proposed method Step-by-step guideline for the proposed method	RQ3
<b>4</b>	Demonstration Application to case study	RQ4
<b>5</b>	Evaluation Survey and workshop result	RQ4
<b>6</b>	Conclusion Answers to the research questions, research contribution, research limitations, future works and recommendations.	All research questions

## 2 Literature Review

This chapter aims to provide and discuss the existing literature on Capability Based Planning (CBP), Project Portfolio Management (PPM), and the relationship between these two concepts. In addition, available tools and techniques for analyzing CBP and PPM will also be discussed in this chapter. Firstly, section 2.1 discusses the relationship between the concepts that are relevant for this research. Section 2.2 and 2.3 explain the concept of CBP and PPM in detail respectively, then in section 2.4 the analysis methods available in the literature will be explained. Lastly, the concept of model-based analysis using Enterprise Architecture (EA) will be discussed in section 2.5.

For the searching strategy of the literature, systematic literature review (SLR) is chosen to be the approach. A systematic review is a means of identifying, evaluating, and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest (Budgen & Brereton, 2006). It is considered important to follow SLR procedure when conducting a research due to several reasons. As also mentioned by Budgen and Brereton (2006), authors will benefit from SLR by having a clear set of procedures to follow in reviewing the material for research, and to identify where this could support or conflict with their own work.

The goal of conducting the SLR is to understand how the concepts of capability based planning, project portfolio management, enterprise architecture, and the relationships between these concepts have been treated in scientific literature. Therefore, the SLR process was done mostly by searching in scientific databases. As additional references, we also include grey literature for example master theses and white papers.

With that in mind, the following databases were selected for the searching process:

- o SCOPUS (<http://www.scopus.com/>)
- o IEEE (<http://ieeexplore.ieee.org/>)
- o ScienceDirect (<http://www.sciencedirect.com/>)
- o JSTOR (<http://www.jstor.org/>)

The selection of the literature is based on the relevance to the research questions. Based on the formulated research questions, the following search keywords are used to find relevant studies in the paper's title, keywords and abstract:

- 1) "capabilities" OR "capability-based planning" OR "capability based planning"
- 2) "capability-based planning" OR "capability based planning"
- 3) "capability analysis" AND techniques
- 4) "capability assessment" AND analysis
- 5) "capability based planning" AND (assessment OR analytical OR analysis)
- 6) "portfolio management" AND (analysis OR techniques)
- 7) "project portfolio management" AND (analysis OR analytical)
- 8) "project portfolio management" AND framework
- 9) "project portfolio management" OR "project portfolio" OR "portfolio management"

- 10) "project portfolio management" AND "capabilities based planning"
- 11) "project portfolio" AND "capability planning"
- 12) "enterprise architecture" AND "portfolio management"
- 13) "enterprise architecture" AND "model-based analysis"
- 14) "enterprise architecture" AND "capability-based planning"

Since the results sometimes are irrelevant, some inclusion and exclusion criteria during research process were defined. The inclusion and exclusion criteria used for this study are listed in the following.

**Inclusion Criteria:**

- (1) The study is reported in English.
- (2) It has the answer to at least one of the research questions stated in section 1.3.2.
- (3) It is relevant to the search terms defined in the previous section.

**Exclusion Criteria:**

- (1) Studies that do not meet the inclusion criteria.
- (2) Studies that are not related to any of the research questions.
- (3) Presentations in slide formats without any associated papers.
- (4) Studies that do not give sufficient information.
- (5) Duplicated studies (by title or content). In the case of duplication, the most recent study will be selected while the duplicated version is excluded.

For the next step, the found literature based on the keywords were filtered based on the above criteria. The criteria were applied by using several filtering processes. First of all, we examined only the title of the papers as a result of the search in each database. At this stage, a lot of papers were excluded since it is not relevant for any of the research questions. The papers that passed this stage were then reviewed in more depth by reading the abstract of the papers. Then, we skimmed through the result to make sure that it is in English and it gives adequate information in order to answer the research questions. Thus, any papers that did not meet these criteria were excluded at this stage. Lastly, we read through the full text of the selected papers to gather findings that are relevant for this research. The result of the searching process, including after applying the defined criteria as explained previously, is shown in the table below.



Table 2 Searching Process Summary

No	Keywords	Scopus	IEEE	Science Direct	JSTOR	After Applying Criteria
1	"capabilities" OR "capability-based planning" OR "capability based planning"	717.035	59.910	955.530	230.521	4
2	"capability-based planning" OR "capability based planning"	67	10	0	17	15
3	"Capability analysis" AND techniques	148	51	424	172	8
4	"Capability assessment" AND analysis	241	77	456	159	5
5	"capability based planning" AND (assessment OR analytical OR analysis)	30	5	5	17	12
6	"portfolio management" AND (analysis OR techniques)	1242	171	5654	7734	27
7	"project portfolio management" AND (analysis OR analytical)	119	27	308	32	15
8	"project portfolio management" AND framework	76	7	249	17	16
9	"project portfolio management" OR "project portfolio" OR "portfolio management"	3860	493	6777	8843	28
10	"project portfolio management" AND "capabilities based planning"	0	0	0	0	0
11	"project portfolio" AND "capability planning"	0	0	0	1	0
12	"Enterprise architecture" AND "portfolio management"	46	59	2	0	5
13	"enterprise architecture" AND "model-based analysis"	4	56	0	0	2
14	"enterprise architecture" AND "capability-based planning"	5	3	0	0	1

As can be seen in the table above, even though each CBP and PPM concept resulted in numerous numbers of papers during the searching process, combination of these two concepts as the keywords does not result in any articles from all the databased used. This means that the idea of combining portfolio management and capability based planning are still pretty much untouched and has not been explored enough in the literature. Moreover, the result is similar in the case of using detail analysis techniques for assessment in CBP. Most of the literature in CBP still lack detailed guideline on how to assess capability performance. Thus, we also looked at the non-academic literature to justify these findings.

As an addition to the SLR, to look for non-academic literature an elaborate search using Google Search (<https://www.google.nl/>) and Google Scholar (<http://scholar.google.nl/>) was executed. Several articles from BiZZdesign consultants were also used for the purpose of the research. In addition, we found several articles and reports from the practical's perspective such as consultants and architects that are related to the topic of the research. This resulted in many reports, articles and white papers written by the practitioner, including military and technical reports.

To sum up, the combination of scientific papers, journals, reports, posts and articles amounted to 112 sources. Each of the selected papers describes the different problem, definitions, and methodologies that are necessary in order to answer the research questions defined in Chapter 1. All definitions and methodologies were considered and evaluated, but not all of them were adopted in the study. Summary of the findings based on these selected papers will be elaborated in more depth in the following section.

## 2.1 Relationship between Strategy, CBP, PPM, and EA

As previously explained in the introduction, the focus of this study will be on the integration of Capability Based Planning (CBP) and Project Portfolio Management (PPM). However, it is also important to set our understanding of these concepts from a high-level perspective. Thus, we also include the concept of Strategy Management (SM) and Enterprise Architecture (EA) to showcase how these concepts are interrelated with each other before the main focus is elaborated thoroughly in the next sub-section.

The main relationship between all of these disciplines is all of them have been studied, more or less separately, in order to achieve strategic alignment in an organization (Buys & Stander, 2010; Cheng, 2015; Kurniawan, 2013; Ulrich & Rosen, 2011). In terms of the definition of strategic alignment, there are multiple definitions available in the literature. The roots of strategic alignment go back almost two decades where academics and researchers have attempted to understand the role of IT in organizations (Al-Hatmi & Hales, 2010; Henderson & Venkatraman, 1993). It is started by the study of Henderson and Venkatraman (1993), in which they argued that the impact of IT on organizations is evolving toward a strategic role which is important to shape new business strategies. Based on Henderson and Venkatraman (1993), strategic alignment is seen as the strategic fit between the position of an organization in the competitive market and the design of an appropriate structure to support its execution. This is also supported by some other studies (Asli et al., 2013; Roelfsema, 2014), in which they stated that strategic alignment should be done in such a way that a strategy is developed while considering the supporting structure (IT) and that operational goals and actions are in line with the overall strategy (business). What is also important to note is that strategic alignment is not an event but instead a process of continuous adaptation and change. Moreover, the cross-domain relationships between different domains need to be recognized in order to achieve strategic alignment (Henderson & Venkatraman, 1993).

In accordance with this perspective of SAM by Henderson and Venkatraman (1993), Adina (2017) also argued that coordination of different disciplines is needed in order to be able to align an organization’s business strategy with its tactics and operations, i.e., with its projects and EA, respectively. In her published dissertation, Aldea (2017) proposed a model to show the link between different disciplines in order to solve the strategic alignment problem, as depicted in the figure below.

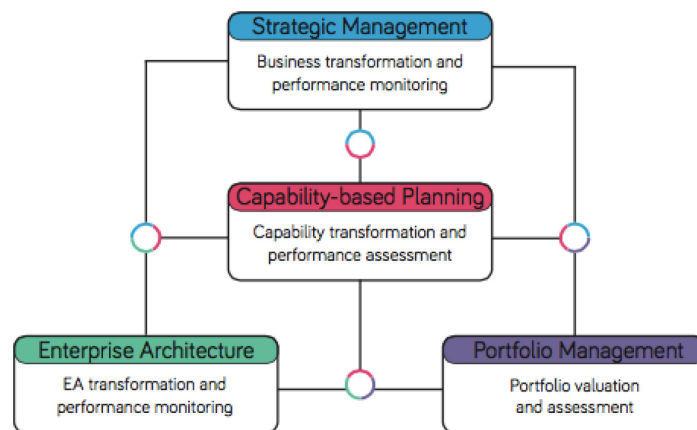


Figure 2 The link between the 4 disciplines (Aldea, 2017)

As seen in the figure above, Strategic Management is at the top of the model. Strategic Management discipline usually deals with strategy formulation and also higher-level properties such as vision, mission, strategic objectives and goals of the organization. Capability-based Planning represents what an organization is able to do and what organization has at a specific time. This includes their resources, information, processes, capabilities, systems, etc. Capability-Based Planning can use information from the Strategic Management domain to determine what capabilities are important in order to realize the strategic objectives of the organization. This information might also be useful in the Portfolio Management domain, to help prioritizing on which capabilities the investments should be made first. In short, Project Portfolio Management is the domain that deals with the management of all kinds of programs, projects, and portfolios in an organization. Not only with Project Portfolio Management, Capability-Based Planning is also closely related with Enterprise Architecture discipline, since the high-level architecture of an organization is represented in capability-based planning.

All of these aforementioned domains are interrelated with each other and together they can be a solution to strategic alignment problems (Aldea, 2017). However, as mentioned at the beginning of this chapter, the main focus of this research will be on the relationship between Capability-Based Planning and Project Portfolio Management. Some elements of Enterprise Architecture will still be incorporated to help shaping the proposed method. This will be explained in more detail in the next section.

## 2.2 Capability Based Planning

In this section, we discuss the concept of capability based planning including its origin, the development, and the application of this concept in the literature, especially in relation with strategic management.

### 2.2.1 Definition and Related Concept

The notions of capability and Capability-Based Planning (CBP) emerged originally in the context of defense planning. It has been adopted by the defense communities mainly in Australia, the United Kingdom, and the United States (Papazoglou, 2014). Other than that, CBP has been applied to the public safety and security domain for example in the United States and the Netherlands. Figure 3 shows the generic process of the CBP method developed by TTCP (2004) as an alternative to threat-based planning, which is a systematic approach to force development for the defense department. It aims to advise the most appropriate force options that should meet the strategic objectives and minimize the cost and risk and comply with the constraint (TTCP, 2004).

Hence, there are different views to define the capability. In the defense area for example, capability is defined as the ability to achieve the desired effect under specified standards and conditions through combinations of means and ways to perform a set of tasks (Kerr et al., 2006). Capabilities are identified based on the tasks required. Once the required capability inventory is defined, the most cost effective and efficient options to satisfy the requirements are sought (TTCP, 2004).

However, this definition refers to capabilities in a highly uncertain environment such as in the defense department, which is not suitable for this research. For the purpose of this research, we use the definition of capabilities given by Iacob, Jonkers, et al. (2012). According to their research, capability is seen as the ability (of a static structure element, e.g., actor, application component, etc.) to employ resources to achieve some goals. For example, 'customer data management' capability is the ability of an organization to manage the personal information of customers in databases (Aldea et al., 2015). Thus, we see capabilities as the ways in which enterprises combine resources, competences, information, processes and their environments to deliver value to stakeholders. These capabilities describe, in general and high-level terms, what the business is able to do (The Open Group, 2011).

The concept of capability based planning has been evolved as a way to develop an organization's competitive advantage and to improve the alignment of Business and IT in the organization (Teece & Pisano, 1994; Zdravkovic et al., 2013). Since then, the concept of business capability has gained a growing attention because it can be used as a baseline for business planning, and it leads directly to service specification and design (Ulrich & Rosen, 2011). More specifically, capability is used to describe what a business can do, which presumably using business terms instead of technical terms. The question about how a business can do it, can be answered by mapping the capabilities with IT deployments through IT or enterprise architectures.

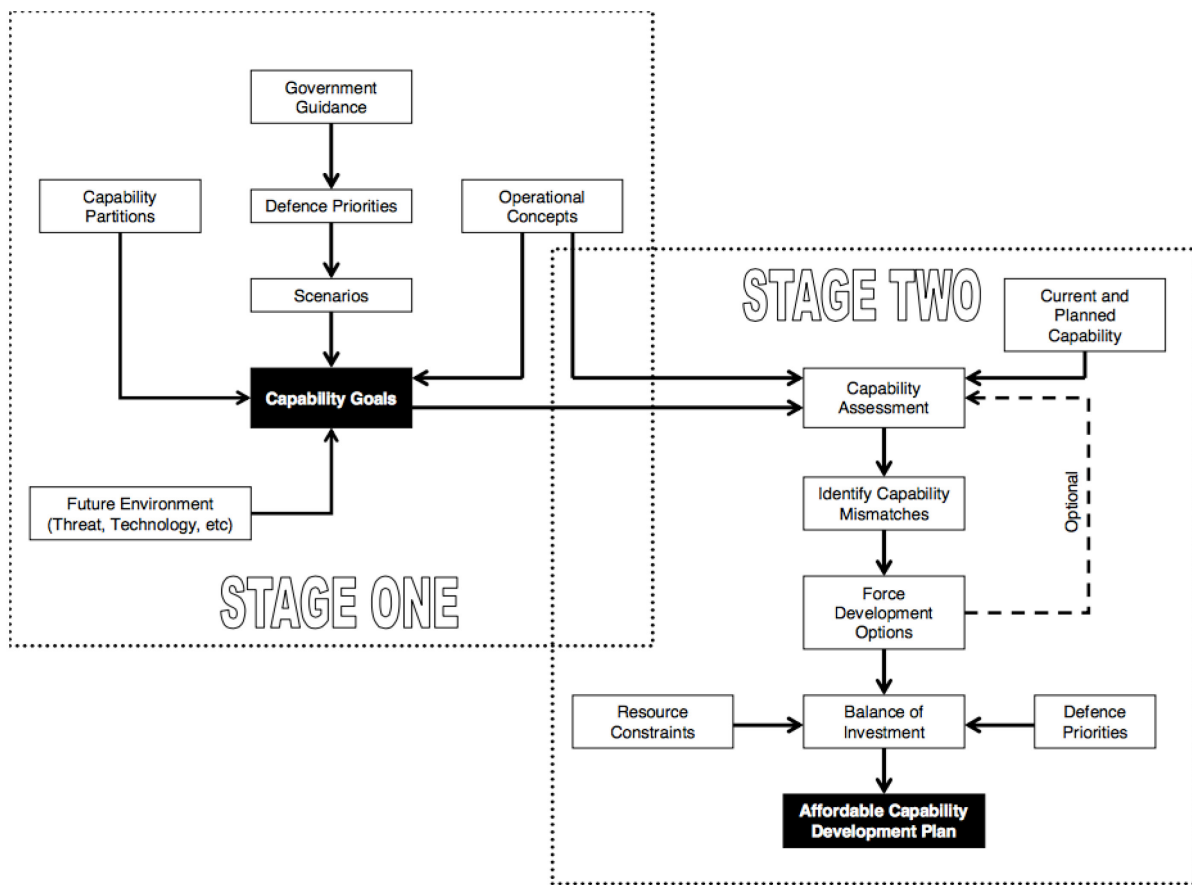


Figure 3 Generic Process Chart of CBP (Chim et al., 2010)

The Open Group (2011) also applies CBP in the context of EA, as it focuses on the planning, engineering, and delivery of strategic business capabilities to the enterprise. It is business-driven and combines the requisite efforts of all lines of business to achieve the desired capability. From an Enterprise Architecture and IT perspective, CBP is a powerful mechanism to ensure that the strategic business plan drives the enterprise from a top-down approach (The Open Group, 2011). Thus, CBP can serve as the method for translating high level strategy into actions (i.e. projects/programs) with the help of enterprise architecture.

### 2.2.2 Capability Based Planning Method

In the literature, there are many views on how the capability based planning should be implemented. However, most of them are specifically made for the defense planning or security domain. Previous study presented by Papazoglou (2014) describes a capability-based method consisting of 3 different activities that can be used in collaboration with TOGAF and modelled with ArchiMate. Other than that, using these three general activities, Cheng (2015) in his master thesis report provides a step-by-step guideline on how to implement the strategy with capability based planning. As a continuation of this study, (Aldea et al., 2015) developed a CBP methodology based on several other views of previous CBP research. The method proposed in her research is presented in the figure below.

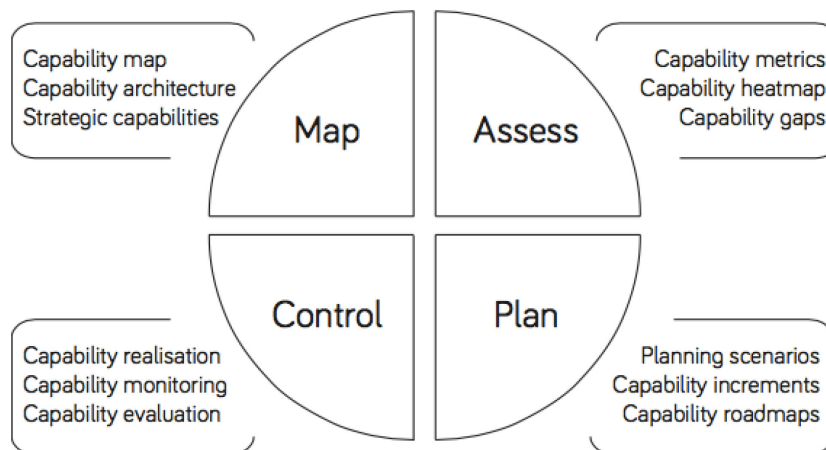


Figure 4 CBP Method Activities (Aldea, 2017)

As shown in the figure, there are four main activities in the proposed CBP method by Aldea (2017). Firstly, we need to identify, describe, and relate the capabilities of the organization. The identification of organization’s capabilities could be done at different levels of aggregation/decomposition. Next step is the assessment phase, which includes the identification of relevant metrics or KPIs and the scoring of these metrics. The Plan phase is related to the planning of capability increments overtime. Lastly, the control phase includes the monitoring of the capability development (planned vs realized level). Based on Aldea (2017), these activities in the method require close collaboration with other relevant areas such as SM, EA, and PPM.

For this research, the main activity that will be focused on is Capability Assessment since it is highly relevant with the goal of the research. More explanation about capability assessment is provided in the section below.

### 2.2.2.1 Capability Assessment

Assessment of capability needs to be performed after capability map has been defined. Based on Ulrich and Rosen (2011), capability map is a blueprint of the capabilities for a given business. This map is a common way for businesses to document and visualize their capabilities within the context of various analysis or planning exercises. The concept of building capability map for strategy planning was also supported by Scott (2009), in which he argued that capability maps are the missing link business strategy and IT action.

After the capability map is defined and specified, the performance of the capabilities needs to be assessed in order to define the right capability development needed to implement a strategy and its objectives successfully. Aldea et al. (2015) in their paper stated that it is necessary to define metrics for each capability. Defining the metric could also help to assess the current and desired performance levels, with monitoring progress and with evaluating the realized outcomes of the improvement.

Taylor (2005) in his report mentioned capability assessment matrix as a way to present the result of the assessment for the defense planning. It is only one of a range of formats available for the presentation of results. An example capability assessment matrix is shown in Figure 5. In this example, the meaning of the colors can vary for example red is major deficiencies, yellow for minor deficiencies, green for sufficient capability and blue for capability affluence.

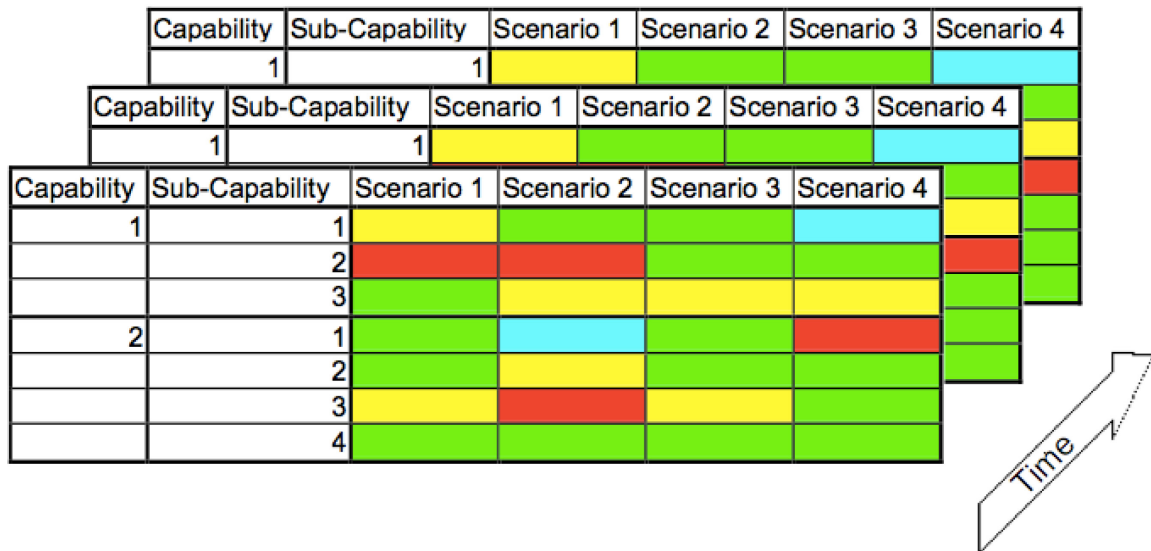


Figure 5 Capability Assessment Matrix (Taylor, 2005)

Moreover, Papazoglou (2014) in his research used the capability maturity level to represent the performance of a capability. It is originally from the Capability Maturity Model (CMM) that was defined by the Software Engineering Institute (SEI). The CMM defines five maturity levels that lay the foundations for continuous process improvement. Achieving each level of the maturity framework establishes a different component in the process, resulting in an increase in the process capability of the organization (Paulk et al., 1993). Along with the CMM, Papazoglou (2014) also used the capability heat map to visualize the capability maturity level, as shown in the figure below.



Figure 6 Example of Capability Heat Map (Papazoglou, 2014)

Capability heat map is a useful tool for visualization of capability performance. Heat map analysis is the first step in determining where to look to address a particular issue (Ulrich & Rosen, 2011). Figure 10 shows an example of a capability heat map. In this example, certain Level 3 capabilities have been marked as underperforming (yellow) or in serious need of attention (red). Those capabilities performing as expected are shown as green, while the capabilities with no color designation have either not been evaluated or are irrelevant.

One of the main objectives of capability assessment is to help with gap analysis in order to determine capability gap and mismatches. This is important to understand which capabilities should be improved, which required time, budget and resource, based on the targets derived from the strategy. The improvement of the capability can be planned on the capability increments. This concept was proposed by The Open Group (2011), along with the notion of capability dimensions. These two concepts were illustrated in Figure 8 below.

It will take some time to deliver a capability and it also could involve several different projects for a capability. Therefore, at any certain point of time, the capability can be presented as a capability increment (The Open Group, 2011). On the other hand, capability dimensions are the sub-set of capability and capability can be managed by its capability dimensions. It could help an organization to explain and understand its capability better. Combined with the concept of capability dimensions, the capability increments can be shown in a radar chart, which is illustrated in Figure 7.



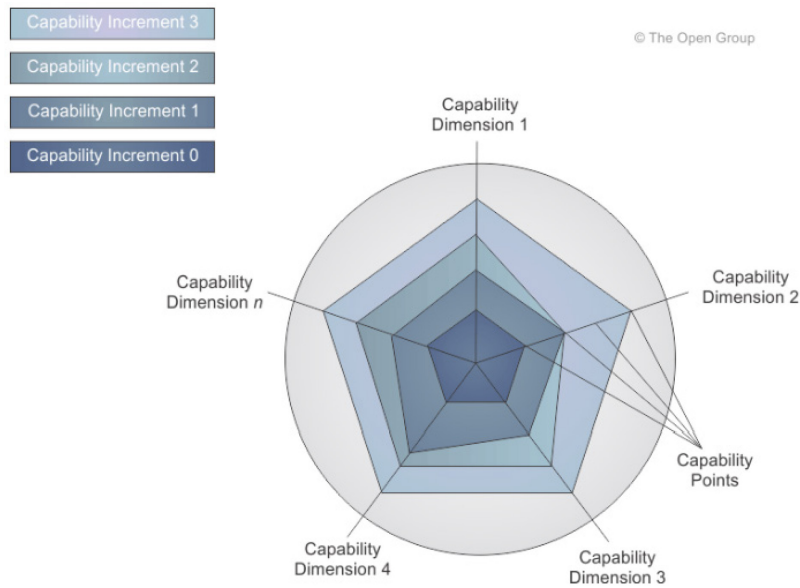


Figure 7 Capability Increment Radar (The Open Group, 2011)

To conclude, there are only a few studies available in the literature that focus on the assessment of capability or capability performance. To sum up, the techniques available for capability assessment as a result of SLR process is presented in table below.

Table 3 Capability Analysis Techniques

Techniques	Reference(s)
<b>Capability Assessment Matrix</b>	(Taylor, 2005)
<b>Capability Gap Analysis</b>	(Ulrich & Rosen, 2011) (Papazoglou, 2014) (Taylor, 2005) (Aldea, 2017) (Cheng, 2015)
<b>Capability Maturity Model</b>	(Papazoglou, 2014) (Cheng, 2015) (Aldea, 2017)
<b>Capability Heat Map</b>	(Scott, 2009) (Aldea et al., 2015) (Papazoglou, 2014) (Cheng, 2015) (Wang, Y., 2016)

From the summary above it can be seen that there are not many techniques available for capability assessment. Capability heat map is included in the list even though it is not really an assessment technique. Capability heat map is only useful to represent the result of capability gap analysis, or to put it simply, it is the visualization of capability gap analysis. Thus, in section 2.4, alternative techniques that can be used for capability analysis will be explored and explained in more detail.

## 2.3 Project Portfolio Management

As organizations increasingly engage in projects to reach their strategic objectives, the effective management and coordination of these projects have become an important task in recent years. In this chapter, detail explanation regarding the concept of project portfolio management will be provided. This includes definition and related concept, available methodologies, and available techniques for PPM analysis.

### 2.3.1 Definitions and Related Concept

There are many available definitions of project portfolio management and the relevant terms. The most used definition is provided by Project Management Institute (2013), in which explained the difference between all the terms used in the project portfolio management area. According to Project Management Institute (2013), the definitions of these terms are presented in the table below.

*Table 4 Definition of Relevant Terms in PPM (Project Management Institute, 2013)*

No	Term	Definition
1	Project	A temporary endeavor undertaken to create a unique product, service, or result.
2	Program	A group of related projects, subprograms, and program activities that are managed in a coordinated way to obtain benefits not available from managing them.
3	Portfolio	Projects, programs, sub portfolios, and operations managed as a group to achieve strategic objectives. The portfolio components may not necessarily be interdependent or have related objectives. The portfolio components are quantifiable, that is, they can be measured, ranked, and prioritized.
4	Project management	The application of knowledge, skills, tools, and techniques to project activities to meet the project requirements
5	Program management	The application of knowledge, skills, tools, and techniques to a program to meet the program requirements and to obtain benefits and control not available by managing projects individually.
6	Portfolio management	The centralized management of one or more portfolios to achieve strategic objectives.

Another definition comes from Blichfeldt and Eskerod (2008), in which PPM is seen as the managerial activities that relate to (1) the initial screening, selection and prioritization of project proposals, (2) the concurrent reprioritization of projects in the portfolio, and (3) the allocation and reallocation of resources to projects according to priority. It shows that portfolio management deals with the business scope related to the goals of an organization. Thus, it combines an organization's focus on ensuring that the selected projects for

investment meet the portfolio strategy with the project management focus of delivering projects effectively and within their planned contribution to the portfolio (Project Management Institute, 2006).

Specifically, the concept of project portfolio management has been evolving since the year of 1952, with the introduction of Harry Markowitz's Modern Portfolio Theory (MPT). In the mid-1990s, the field of PPM received increasing attention in which the portfolio investment techniques were used to manage projects in the organization (De Reyck et al., 2005). During its development, it has also been argued that employment of PPM in organizations can lead to an improvement in strategy implementation and project delivery success rates, or in other words, bridging the gap between strategy development and strategy implementation (Buys & Stander, 2010).

Project portfolio management concept consists of numerous elements and aspects. Padovani and Carvalho (2016) in their paper made an attempt to summarize and identify the core elements and processes in project portfolio management. The result is shown in Figure 8 below. A precise description of each construct and the activities within is explained in Appendix 1.

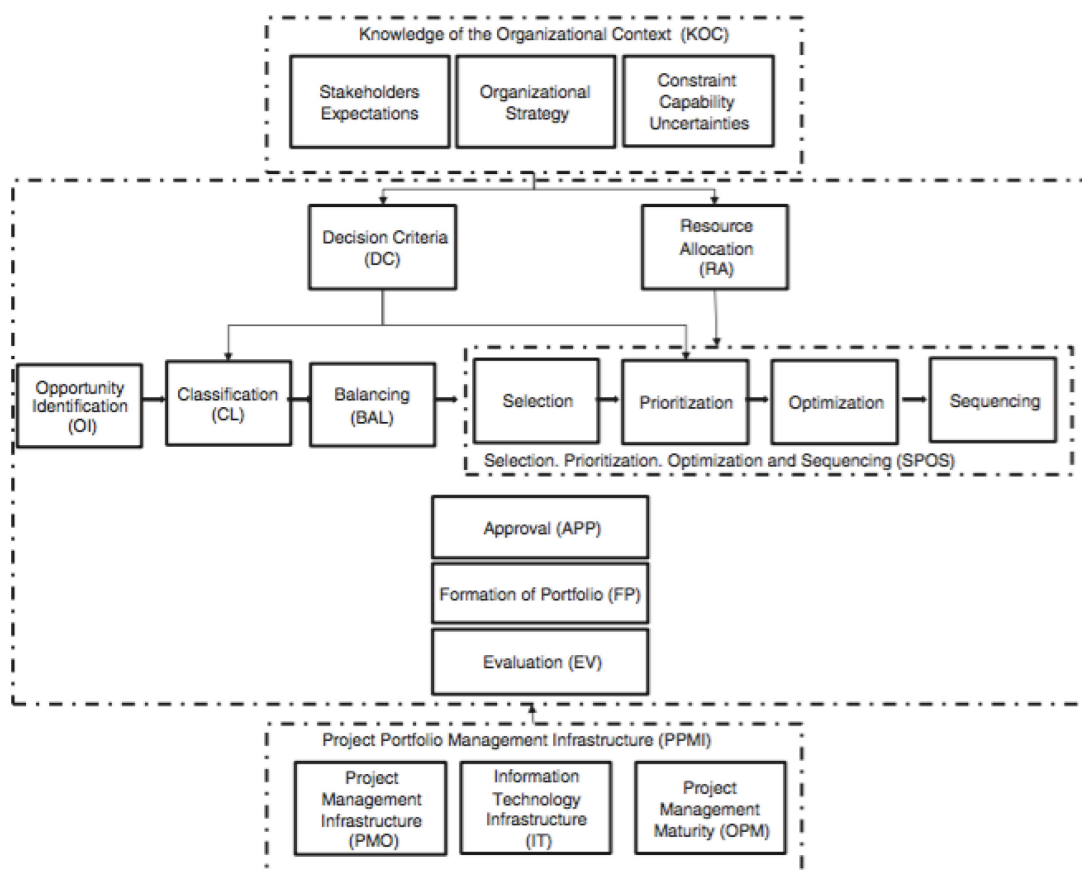


Figure 8 PPM Constructs (Padovani & Carvalho, 2016)

The focus of this study is mainly in the right middle area of the figure, which consists of a set of PPM processes, receiving from the top level the decision criteria and the resource to be

allocated in order to select and prioritize projects. To select and prioritize the most feasible projects, obtaining a portfolio with the highest value and which meets the needs of the organization, requires clarity about the organization's goals and objectives and decision criteria that are aligned and defined with the main stakeholders (Cooper, R. et al., 2001).

In the figure above, prioritization, optimization and sequencing (SPOS) are considered together because these processes are usually combined in the literature. It is performed by applying operational research techniques that encompass all these processes with the objective to select the best project based on specified criteria. A more comprehensive explanation of the project selection process along with available techniques for project selection will be presented in section 2.3.3.

### 2.3.2 PPM Methodologies

In order to understand the concrete process of project portfolio management, some methodologies are selected based on the completeness of the methods and its relationship with the objectives of this research. The selected methodologies are discussed in the following section.

#### 2.3.2.1 BiZZdesign Enterprise Portfolio Management (Bodenstaff et al., 2014)

Enterprise portfolio management (EPM) is defined as an integrated portfolio management approach that tightly manages strategy planning against the various portfolios of interdependent assets, like product portfolios and project portfolios. In their paper, Bodenstaff et al. (2014) discussed why EPM is important for an organization and what are the elements needed in the EPM. In addition to that, they also raised the question on how to implement the EPM process. Even though the steps to implement a portfolio management might vary in organizations, Bodenstaff et al. (2014) argued that several key elements must be present to make sure the implementation process will be successful. These key elements are presented Figure 9 below.

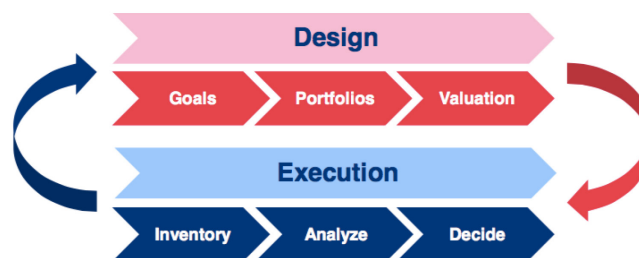


Figure 9 EPM Cycle (Bodenstaff et al., 2014)

The cycle consists of two phases: the design phase and the execution phase which contains three activities respectively. In the design phase, the relevant stakeholders firstly define their goals and afterwards the portfolios are aligned with the goals, and finally the stakeholders formulate a valuation model that conveys their concerns. In the execution phase, the stakeholders store and analyze assets and projects first. Subsequently, they visualize the portfolio score of the applicable metrics, which are depicted in the dashboard to facilitate

their concerns. Dashboards are a powerful way to address such concerns in a direct way (Bodenstaff et al., 2014). Finally, decision-making on investments in assets or projects can be made using the result in the portfolio as an input review.

First, the goals need to be defined, along with the portfolio based on the concern of the decision-maker. A valuation model is then carried out to give a prioritization of the proposed projects or assets and finally to execute the portfolio as well as monitor and keep this process as a lifecycle instead of a finite process.

#### *2.3.2.2 IT Portfolio Framework (Handler & Maizlish, 2005)*

As mentioned in the book by Handler and Maizlish (2005), IT portfolio management provides the tools, processes, and disciplines needed to translate information technology into a common taxonomy that both business and IT executives understand. Moreover, they stated that the goal of an IT portfolio is to deliver measurable business value, both tangible and intangible, while aligning and improving the business and IT strategy.

Based on this definition, they discussed eight key stages in building the IT portfolio in detail. These eight stages are considered as the most important contribution of their book. For each stage, they also presented its sub-elements (e.g., tasks, outputs, and skill requirements) along with images to illustrate the steps and processes. Summary of the eight key stages defined by Handler and Maizlish (2005) will be discussed in the following list.

1. Develop an IT portfolio management game plan: to specify the objective of IT portfolio management.
2. Planning the IT portfolio: to determine the investment strategy.
3. Create IT portfolio: to create and store both current and planned projects. The as-is portfolio is captured in a standardized business case and located in a centralized database. Defining the project's metric and building a portfolio view to compare investments against each other. The assessment can be made in the basis of several dimensions such as technical condition, business value, and risk. Thus, a consistent and standardized set of criteria with threshold levels should be established.
4. Assess IT portfolio: to assess and measure the portfolio against the target continuously, while taking into account the internal and external possible trigger events. The review process should be conducted at least on a quarterly basis. It also suggests frequently evaluating and updating the business case for each project.
5. Balance IT portfolio: Identification of the optimal allocation of investment by determining trade-offs within the portfolio. The portfolio refers to the investments that have been selected and funded by the same committee.
6. Communicate IT portfolio: It suggests that the communication regarding the goals, status and what needs to be changed in the portfolio must occur throughout all phases to the entire relevant stakeholder.
7. Develop and evolve IT governance and organization: This stage defines the roles and responsibilities in the portfolio management process.
8. Assess IT Portfolio management process execution: Finally, the execution of the projects is evaluated based on the goals defined in the game plan (stage 1).

An overview of the framework proposed by Handler & Maizlish (2005) is illustrated in the figure below.

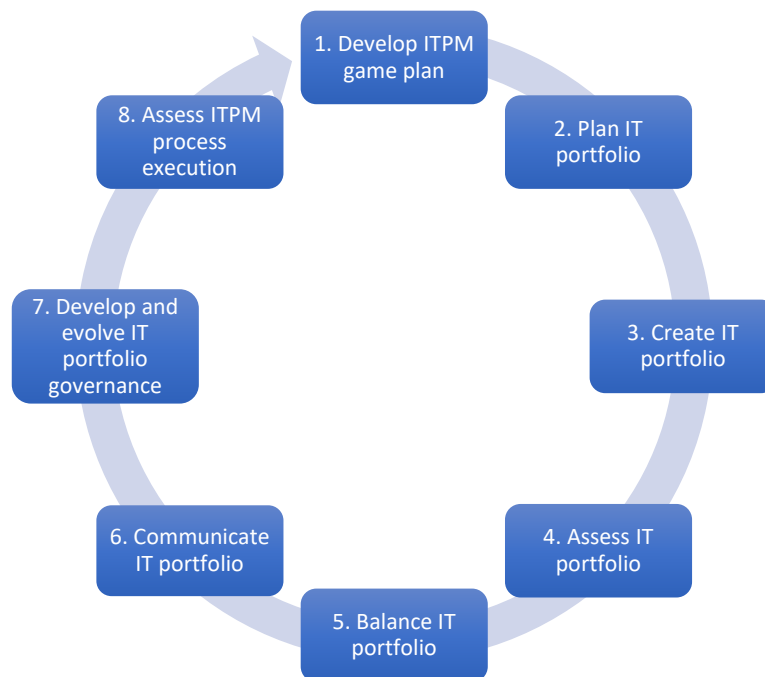


Figure 10 Eight stages of IT Portfolio Management Process (Handler & Maizlish, 2005)

### 2.3.3 Project Portfolio Selection Process

Project portfolio management and project portfolio selection are understood in a slightly different manner. It is explained as follow. Project portfolio selection is understood as a dynamic decision-making process to evaluate, select and prioritize a project or a set of projects for implementation through allocation of constrained resources and alignment with corporate strategies (Archer & Ghasemzadeh, 1999; Cooper, R. et al., 2001), while project portfolio management is inclusive of project management in addition to the process of project portfolio selection as explained above.

For this research, as explained in the previous section, the focus will be more on the project selection in the context of project portfolio management. Selecting right projects and the right mix of projects for the portfolio is considered as one of the most important tasks for the organizations to ensure the achievement of the corporate strategy within limited resources and capabilities of the organizations. Many discussions in the literature acknowledged that the right sets of projects for implementation of corporate strategies importantly result from successful selection of project portfolio (Archer & Ghasemzadeh, 1999; Cooper, R. et al., 2001; Ghasemzadeh & Archer, 2000)

Archer and Ghasemzadeh (1999) in their paper developed a project portfolio selection framework, as a simplification of the overall project portfolio selection process. This framework consists of several stages in which each stage achieves a distinct objective and generates inputs for the next stage. At the same time, users are free to choose the techniques they found the most suitable for each stage, or in some cases to omit or modify a stage if this will simplify the process. The framework is shown in the figure below.

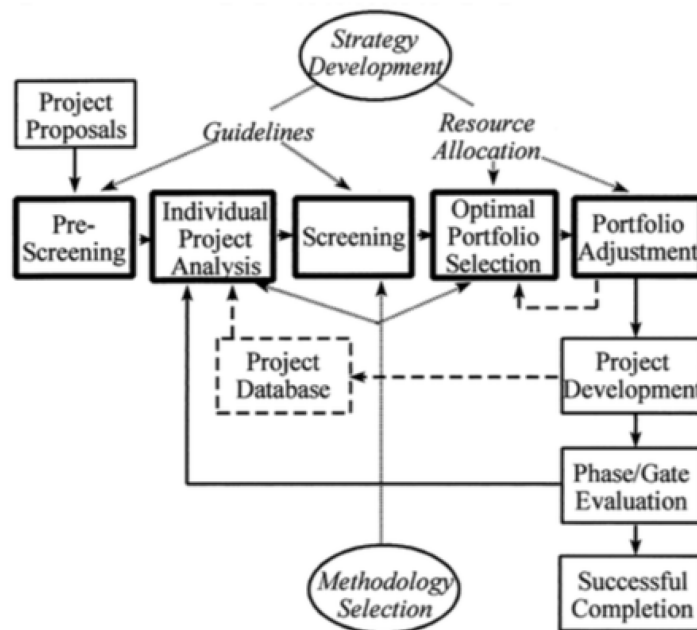


Figure 11 Project Portfolio Selection Framework (Archer & Ghasemzadeh, 1999)

Since one of the main focus of this research is to develop an analysis method, it is important also to identify the potential techniques that can be used for analysis purpose in the different stages of project selection process. Iamratanakul et al. (2008) in their paper presented a comprehensive summary of project portfolio selection methods that are available in the literature until the year of 2008. They categorized the methods into six groups of project portfolio selection methods, as shown in the figure below.

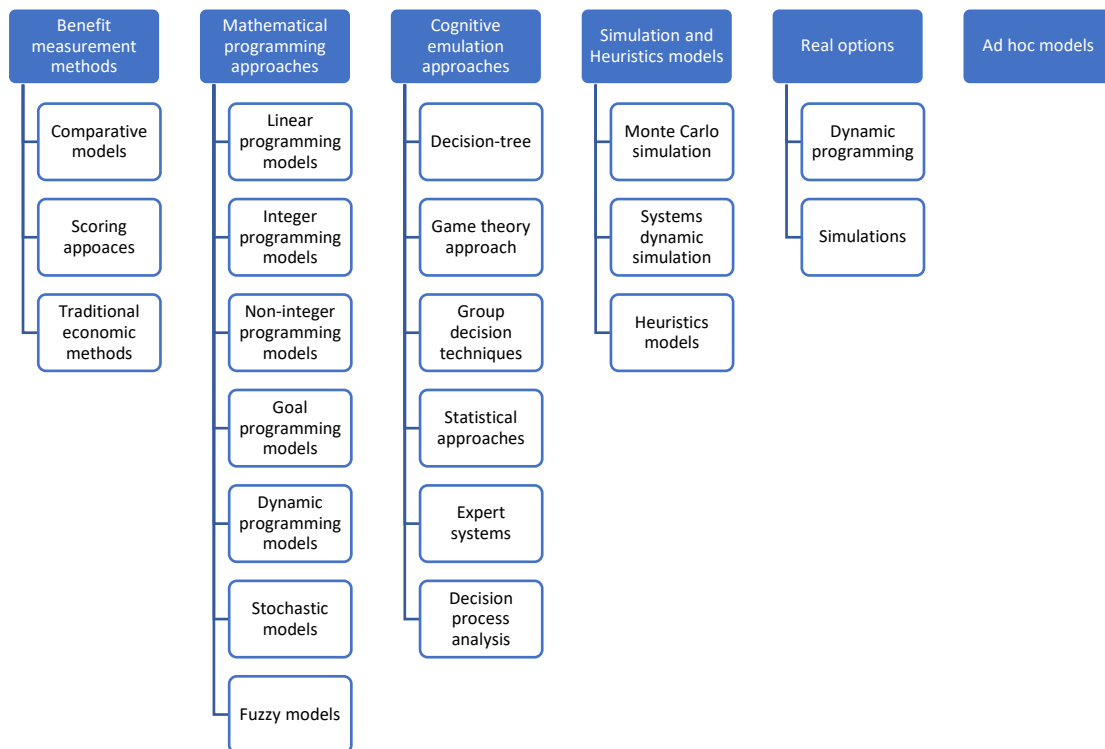


Figure 12 Models for project portfolio selection (Iamratanakul et al., 2008)

Comparative models are used for evaluating a group of projects by relating one project proposal either to another project proposal or to some subset of alternative project proposals. The scoring models are methods for ranking candidate projects relative to one another. The linear programming models are quantitative tools for project portfolio selection using linear programming (LP). Decision-tree approach is used to represent and analyze a series of R&D investment decisions to be made over time, often under the condition of uncertainty. In general, a decision-tree approach deals with situations in which the decision maker faces a series of choices and chance outcomes following each choice.

For the simulation, one example that is commonly used is Monte Carlo simulation. Monte Carlo simulation uses probability distributions of all stochastic elements in an R&D program to calculate the overall probability distribution of objective values and means spent. On the other hand, real option is an approach to projects valuation, which incorporates both the uncertainty inherent in business and the active decision making required for a strategy to succeed. Real options start with mapping an investment opportunity onto a call option. To do so, it needs to establish variables that determine project characteristics and the value of simple call options. The last kind of techniques, the ad hoc models, are another type of models which are unstructured and built for a specific purpose in an organization.

The model above presented by Iamratanakul et al. (2008) is quite comprehensive and sums up the available techniques for project portfolio analysis in the literature. In addition to this, there is also financial methods such as the calculation of Net Present Value (NPV), Return on Investment (ROI), or Payback Period (PP) (Cooper, R. et al., 2001). A summary of available



techniques and methods that can be used in the project selection process is presented in Table 5 below.

Table 5 Project Selection Techniques

Process	Potential Techniques	References
<b>Individual project analysis/ Project valuation</b>	Decision trees Uncertainty estimates Financial methods (NPV, ROI, PP)	(De Reyck et al., 2008) (Levine & Wideman, 2010) (Archer & Ghasemzadeh, 1999) (Rajegopal et al., 2007) (Berghout & Renkema, 2001)
<b>Portfolio/ Project Selection</b>	MCDAs methods (AHP, MAUT, etc) Constrained Optimization Scoring Models Linear programming	(Archer & Ghasemzadeh, 1999) (Danesh et al., 2015) (Dinesh Kumar et al., 2007) (Karasakal & Aker, 2016) (Asosheh et al., 2010)
<b>Portfolio Optimization</b>	Constrained Optimization Linear programming Integer programming Quadratic programming Stochastic programming	(Mansini et al., 2015) (Iamratanakul et al., 2008) (Amaral & Araújo, 2009) (Sen et al., 2006)
<b>Resource Allocation</b>	Real options Mathematical programming model Scoring models Decision tree analysis Simulation models	(McKinven et al., 2002) (Dobrovolskienė & Tamošiūnienė, 2014) (Klingebiel & Adner, 2015)

Compared to the available techniques for capability assessment, methods that can be used in project portfolio selection are quite extensive in numbers. Thus, we have to make selection since it is not possible to use all of these techniques for the proposed method. After careful consideration, it is decided that the Multi Criteria Decision Analysis (MCDA) methods will be explored furthermore, since the main objective is to focus on the project selection process. The result of the literature review regarding available decision-making tools and techniques, specifically concerning MCDA methods, will be presented in section 2.4.

#### 2.4 Decision Making Tools and Techniques

Individuals and institutions face numerous decision problems on a daily basis. In many of these cases, the decision-making process involves not only one criterion, but a large number of points of comparison. For these issues, multi-criteria decision analysis (MCDA) was developed. MCDA is both an approach and a number of techniques, used to provide priorities or rankings for several alternatives in complex decision problems (Ishizaka & Nemery, 2013).

The most suitable solution for the decision maker to a problem is determined by focusing on the decision maker and gaining subjective preference information (De Montis et al., 2004).

Multi-Criteria Decision Analysis, or MCDA, is a valuable tool that we can apply to many complex decisions. It is most applicable to solving problems that are characterized as a choice among alternatives. It has all the characteristics of a useful decision support tool: It helps to focus on what is important, is logical and consistent, and is easy to use. MCDA is useful for different purposes, for example to divide problems into smaller and more understandable parts, to help analyzing these parts, and to integrate these to produce a meaningful solution.

MCDA has grown in recognition due to its ability to tackle problems involving more than one objective. Several studies in the literature (Greco et al., 2005; Velasquez & Hester, 2013; Wang, J.-J. et al., 2009) showed that MCDA provides a useful tool for decision-making in a real world, as it allows for multiple objectives for the use of different types of data and the involvement of different stakeholders. Thus, this tool could be applicable to all kinds of problems, making it favorable to be used in a lot of different fields. The choice of a particular method depends on the specific problem as well as on the users' demands. As the number of existing methods is already quite large and is still increasing, the selection of the 'right' method to be used is not an easy task.

Ishizaka and Nemery (2013) in their book provided a very comprehensive and complete explanation of each available MCDA methods, including the differences between each other and the application of each method to solve various decision problems. The summary of available MCDA methods described in the book is illustrated in the figure below.

Full Aggregation Approach	Outranking Approach	Goal, Aspiration, or Reference Approach
<ul style="list-style-type: none"> <li>• Analytic Hierarchy Process</li> <li>• Analytic Network Process</li> <li>• Multi Attribute Utility Theory</li> <li>• MACBETH</li> </ul>	<ul style="list-style-type: none"> <li>• PROMETHEE</li> <li>• ELECTRE</li> </ul>	<ul style="list-style-type: none"> <li>• TOPSIS</li> <li>• Goal Programming</li> <li>• Data Envelopment Analysis</li> </ul>

Figure 14 Summary of MCDA Methods (Ishizaka & Nemery, 2013)

There are different ways of choosing which appropriate MCDA methods to solve specific problems. One way is to look at the required input information, that is, the data and parameters of the method and consequently the modelling effort, as well as looking at the outcomes and their granularity. If the 'utility function' for each criterion (a representation of the perceived utility given the performance of the option on a specific criterion) is known, then MAUT is recommended. However, the construction of the utility function requires a lot of effort and is quite difficult, so there are alternatives for this. Another way is by using pairwise comparisons between criteria and options, such as AHP and MACBETH to support this approach. AHP is easier to use and easier to understand, but both pretty much do the

same thing. The difference is that comparisons are evaluated on a ratio scale for AHP and on an interval scale for MACBETH. The decision maker needs to know which scale is better suited to yield their preferences. The drawback is that a large quantity of information is needed. On the other hand, outranking methods are based on pairwise comparisons. This means that the options are compared two-by-two using an outranking or preference degree. The preference or outranking degree reflects how much better one option is than another.

As can be seen from Figure 14 above, there are numerous MCDA methods that have been developed and utilized over the past decades. Each method has its own benefit and limitation, and usually different areas of application in the industry. It is also possible to combine different methods and apply it to solve decision problems. It is becoming a trend to combine several methods together, since it can address the deficiencies that may be seen in certain methods. Velasquez and Hester (2013) in their paper identified the common methods in MCDA and examined the advantages and disadvantages of each identified method. A summary of their findings, with an additional explanation for each method is presented in Appendix 2.

Ishizaka and Nemery (2013) also argued that when facing a decision problem, it is important to define the type of output required from the beginning. They provided the information on the expected input and output for solving ranking or selection problem, as presented in Figure 13.

	Inputs	Effort input	MCDA method	Output
<b>Ranking/ choice problem</b>	utility function		<b>MAUT</b>	Complete ranking with scores
	pairwise comparisons on a ratio scale and interdependencies		<b>ANP</b>	Complete ranking with scores
	pairwise comparisons on an interval scale		<b>MACBETH</b>	Complete ranking with scores
	pairwise comparisons on a ratio scale		<b>AHP</b>	Complete ranking with scores
	indifference, preference and veto thresholds		<b>ELECTRE</b>	Partial and complete ranking (pairwise outranking degrees)
	indifference and preference thresholds		<b>PROMETHEE</b>	Partial and complete ranking (pairwise preference degrees and scores)
	ideal option and constraints	<b>Goal programming</b>	Feasible solution with deviation score	
ideal and anti-ideal option	<b>TOPSIS</b>	Complete ranking with closeness score		
no subjective inputs required	Very LOW	<b>DEA</b>	Partial ranking with effectiveness score	

Figure 13 Required inputs for MCDA ranking or choice methods

Other than MCDA methods, there are also other kinds of techniques that might be useful especially in the area of PPM. For example, financial analysis is important since we need to be able to estimate the financial elements of projects and programs in the portfolio. Thus, valuation techniques could also be used.

Based on careful consideration of the benefit and limitations of each method in mind, AHP and DEA were selected for the purpose of this research since it is highly relevant to the

objective of the thesis. As can be seen in the comparison table above, AHP is a very subjective method, on which it relies heavily on the judgment of experts. On the other hand, DEA does not require any subjective inputs, with the assumption that all data is known and precise. Thus, a combination of these two methods for capability and project analysis is proposed to overcome the shortcomings of each method when applied individually.

Analytical hierarchy process (AHP) was developed by Saaty (1988) as a comprehensive, logical, and structural framework, to facilitate the understanding of complex decisions. It allows a decision-maker to structure a complex multi-alternative in the form of a hierarchy of projects or other alternatives such as products at the bottom level and the various objectives at respective higher levels (Saaty, 2008).

Based on Ishizaka and Nemery (2013), to use the AHP method the user needs to complete four steps to obtain the ranking of the alternatives. Firstly, the problem has to be structured. In the next step, scores or priorities are calculated based on the pairwise comparisons provided by the user. The decision maker does not need to provide a numerical judgement; instead a relative verbal appreciation, more familiar to our daily live, is sufficient. There are two additional and optional steps that can be carried out, which are a consistency check and a sensitivity analysis. Even though they are optional, it is still recommended to perform both steps as confirmation of the robustness of the results of AHP.

The AHP has frequently been applied in a variety of settings over the past years. It was argued to be a very powerful and flexible tool that can be very useful for structuring a problem, for group decision making and very complex decision problems. Nonetheless, the AHP has also been criticized by various authors in the literature. The rank reversal is surely the most debated problem. This phenomenon is still not fully resolved and maybe it will never be because the aggregation of preferences transposed from scales of different units is not easily interpretable and even questionable according to the French school (Ishizaka & Labib, 2011).

Despite the criticism about different aspects of the AHP, this method is rather likely to be increasingly used in different applications in the future. This might be motivated by the intuitive structure, the simplicity of the application and its flexibility, and the large amount of supporting software (Ishizaka & Labib, 2011).

On the other hand, Data Envelopment Analysis (DEA) is a commonly used approach to the measurement of efficiency. It was first introduced by Charnes et al. (1978) and since then DEA has been applied to various areas such as healthcare, transportation, bank, insurance, logistics, ICT, etc. It is used to measure the performance of firms or entities (called decision-making units, DMUs) which convert multiple inputs into multiple outputs. This is one of the advantages of DEA, since it allows multiple outputs and multiple inputs to be taken into account.

What distinguishes DEA from other methods is that the weights assigned to outputs and inputs are not allocated by users. Moreover, it does not rely on a common set of weights for all firms. Instead, a different set of weights is calculated by a linear optimization procedure in order to show each firm in its best possible light.

Based on Ishizaka and Nemery (2013), DEA can help decision makers in the following ways:

- o By calculating an efficiency score, it indicates if a firm is completely efficient or has the capacity for improvement.
- o By setting target values for input and output, it calculates by how much input must be decreased or output increased in order to become efficient.
- o By identifying the nature of returns to scale, it indicates if a firm has to decrease or increase its scale (or size) in order to minimize the average total cost.
- o By identifying a set of benchmarks, it specifies which other firms' processes need to be analyzed in order to improve its own practices.

Some studies in the literature have been adopted the application of DEA method in project portfolio management. Asosheh et al. (2010) proposed an approach that integrates DEA and Balanced Scorecard for IT project evaluation. The proposed approach used BSC as a comprehensive framework for defining IT projects evaluation criteria and used DEA as a nonparametric technique for ranking the IT projects. Karasakal and Aker (2016) in their paper also developed a DEA-based method to evaluate research & development projects. In addition, other researches that use DEA approach in PPM have been developed in the last decades (Dinesh Kumar et al., 2007; Linton et al., 2002; Sowlati et al., 2005).

Moreover, a DEA model can be input or output-oriented. In an input orientation, DEA minimizes input for a given level of output. On the other hand, in an output orientation, DEA maximizes output for a given level of input. This orientation depends a lot on the algorithm behind the model and the objective function of the model. Since numerous models are available, a summary of some basic DEA models available in the literature is summarized in Table 6 below.

*Table 6 Summary of Basic DEA Models (Cooper et al., 2006)*

Model/ Origin	Returns to scale	Orientation	Objective Function
<b>Charnes-Cooper-Rhodes or CCR (original model)</b>	Constant return to scale (CRS)	Input-oriented	Minimize inputs while producing at least the given output levels
		Output-oriented	Maximize outputs while using no more than the observed amount of any input
<b>Baker-Charnes-Cooper or BCC (alternative model)</b>	Variable return to scale (VRS)	Input-oriented	Minimize inputs while producing at least the given output levels
		Output-oriented	Maximize outputs while using no more than the observed amount of any input

For this research, the decision-making units (DMUs) are considered as the projects to be assessed. Other criteria and entities that need to be taken into consideration when selecting projects are seen as either input or output in the DEA model. Explanation about the input and output selection for the DEA model is described in Chapter 3.

## 2.5 Enterprise Architecture: Modelling with ArchiMate

The concept of Enterprise Architecture (EA) has been evolved over the last decade in both the literature and in practice. By definition, EA is a conceptual tool that helps organizations get a deeper understanding of their own structure and of the way they work. It provides a map of the enterprise and it is a “route planner” for business and technology change (Iacob, Jonkers, et al., 2012). In their paper, Iacob, Jonkers, et al. (2012) also specify the concept of EA as a complete, consistent and coherent set of methods, rules, models and tools which guides the (re)design, migration, implementation and governance of business processes, organizational structures, information systems and the technical infrastructure of an organization according to a vision.

From the practical perspective, EA is defined as a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise’s organizational structure, business processes, information systems, and infrastructure (Lankhorst et al., 2013). Since EA captures a holistic view of the enterprise, it can be used by an organization to steer decision making towards the evolution of the future state architecture. Thus, enterprise architecture plays a central role in the implementation, from business strategy to business execution. Conversely, it also plays an important role in support of organizational governance.

An organization typically will apply the concept of enterprise architecture by following a specific EA framework, which maps all of the software development processes within the enterprise and how they relate and interact to fulfill the enterprise’s mission (Urbaczewski & Mrdalj, 2006). Furthermore, Iacob, Jonkers, et al. (2012) determine three ingredients in Enterprise Architecture which are a framework, a language and a process. A framework represents the subdivision of architecture in different domains including the relationship between these domains. A language defines the concepts for describing an architecture while a process provides a step-wise prescriptive method for developing architectural descriptions.

The elements of enterprise architecture that will help with this research is the modelling of the architecture as the basis to conduct the model-based analysis. A model-based analysis is considered important to achieve optimal organizational effectiveness. Lankhorst et al. (2013) in their book argued that to create an integrated perspective of enterprise architecture, both a description technique for architectural models and model-based analysis techniques are needed to realize the global optimization in practice. The reason is model-based analysis plays a central role whenever a change in the enterprise architecture is needed or performed. Thus, in order to realize this model-based analysis, a modelling language that supports EA framework is needed in this research for building the EA model.

With that in mind, the ArchiMate language is considered as the best and the most common language for developing the architecture. Griffioen and Hofman (2012) in their research argued that the reason to choose ArchiMate above other formal languages in EA as a language was because it is an open standard. Moreover, ArchiMate is particularly attractive, mainly due to the usage of visual representation, and the fact that it encourages the use colors to highlight the different modelling layers. ArchiMate also opts for one unique language (UML) to model every layer of the architecture, which eases the communication when teams responsible for the different layers need to collaborate (Fritscher & Pigneur, 2011). It offers an integrated architectural approach that describes and visualizes different architecture domains and their underlying relations and dependencies. Its language framework provides a structuring mechanism for architecture domains, layers, and aspects (The Open Group, 2016).

The ArchiMate language consists of different aspects and layers that together make up a framework known as ArchiMate Core Framework (The Open Group, 2016). The dimensions of the core framework of ArchiMate are explained as follows:

- Layers: The three levels at which an enterprise can be modelled in ArchiMate:
  - o Business Layer – depicts business services offered to customers, which are realized in the organization by business processes performed by business actors.
  - o Application – depicts application services that support the business, and the applications that realize them.
  - o Technology – depicts technology services such as processing, storage, and communication services needed to run the applications, and the computer and communication hardware and system software that realize those services.
- Aspects:
  - o The Active Structure Aspect, which represents the structural elements (the business actors, application components, and devices that display actual behavior; i.e., the “subjects” of activity).
  - o The Behavior Aspect, which represents the behavior (processes, functions, events, and services) performed by the actors. Structural elements are assigned to behavioral elements, to show who or what displays the behavior.
  - o The Passive Structure Aspect, which represents the objects on which behavior is performed. These are usually information objects in the Business Layer and data objects in the Application Layer, but they may also be used to represent physical objects.

In the recent development of ArchiMate language, ArchiMate 3.0 specification by The Open Group (2016), three layers and one aspect were added to the framework. Firstly, the physical elements were built upon the technology later to add elements for modelling physical facilities and equipment, distribution networks, and materials. The motivation aspect was also introduced at a generic level to model the motivations, or reasons that guide the design or change of an enterprise architecture. Lastly, implementation and migration layer was also added for architectural elements that are related with implementation processes such as deliverables, work packages, and etc. The summary of the concept in the full ArchiMate framework based on ArchiMate 3.0 specification is presented in Figure 14 below.

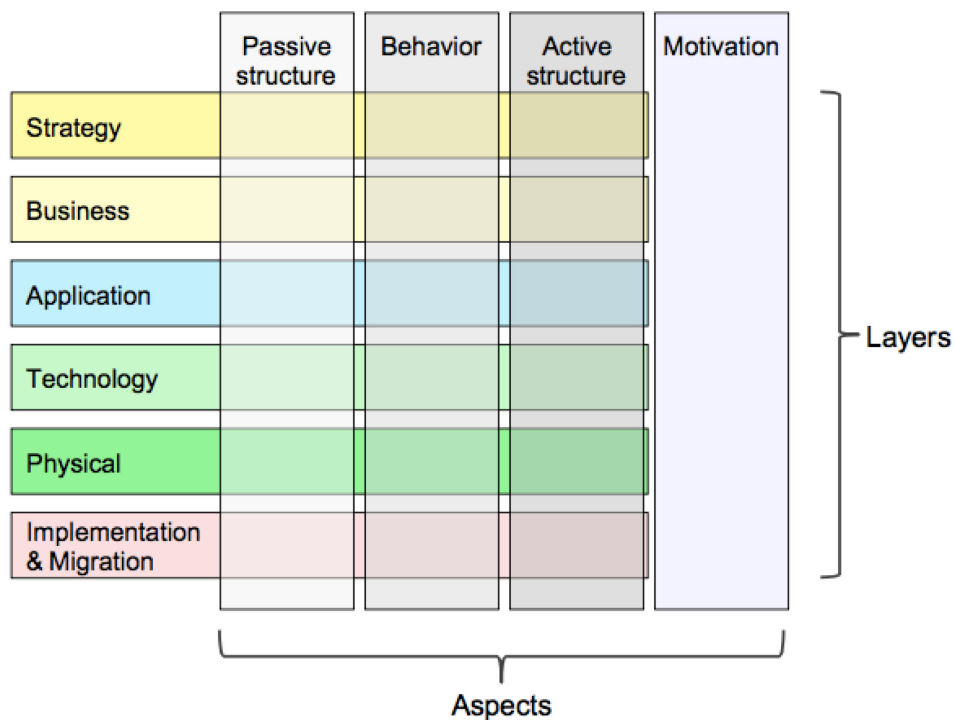


Figure 14 Full ArchiMate Framework (The Open Group, 2016)

As can be seen in the above figure, ArchiMate consists of many blocks as a combination of different layers and aspects. Since we want to use ArchiMate for modelling, it is important to note that in modelling we need the concept of elements and relationships. An element could be part of any of the blocks in the framework above (e.g. a behavior element or motivation element), while a relationship connects a source and target concept (could be either element or other relationship). A complete explanation regarding the core elements and relationships along with their definitions is provided in the book by The Open Group (2016). In the next section, some related analysis needed along with the appropriate modelling concept in ArchiMate will be explained with the purpose to define the theoretical framework required for this study.

### Impact analysis

Impact analysis is the activity of identifying what to modify to accomplish change, or of identifying the potential consequences of change (Arnold, Robert S & Bohner, 1993). The techniques available for impact analysis varies from quantitative impact analysis to argumentative or qualitative analysis. In addition, several attempts have been made in conducting change impact analysis based on the enterprise architecture. Langermeier et al. (2014) proposed a context-sensitive impact analysis technique for EA models using data-flow analysis method based on defined propagation rules for the most important relationships in ArchiMate models. This includes the removal, extension, and modification of an architectural element. In addition, *no change* is also used when there is no impact on the architectural element. A summary of the propagation rules for change impact defined in their paper is illustrated in the table below.



Table 7 Impact rules for different relationships (Langermeier et al., 2014)

Class (Archimate)	Class (in the paper)	Rule
<b>Assigned to</b>	<b>Located at</b>	A.(del,mod,ext) → B.NO B.del → WC: A.del BC: A.ext B.(ext,mod) → WC: A.mod BC: A.NO
<b>Realizes, accesses</b>	<b>Provides</b>	A.del → WC: B.del BC: B.ext A.mod → WC: B.mod BC: B.NO A.ext → WC: B.ext BC: B.NO
<b>Uses, accesses</b>	<b>Consumes</b>	A.(del,mod,ext) → B.NO B.(del,mod) → WC: A.mod BC: A.ext B.ext → A.NO
<b>Aggregated by, composed by</b>	<b>Structurally dependent on</b>	A.del → WC: B.del BC: B.mod A.(mod,ext) → B.NO B.(del,mod) → WC: A.mod BC: A.NO B.ext → WC: A.ext BC A.NO
<b>Triggered by, flow from</b>	<b>Behaviorally dependent on</b>	A.(del,mod,ext) → B.NO B.(del,mod,ext) → A.NO

Still related to change impact analysis for enterprise architecture, Sunkle et al. (2013) in their paper also proposed a technique for EA change impact analysis with ontology. They argued that the basic idea of change impact analysis in EA is centered around a set of heuristic rules based on the nature of relations that connect concepts. Figure 15 below shows the heuristic rules for various Archi-Mate relations based on Sunkle et al. (2013).

Relation X	When Concept A <X> Concept B	Notes
<i>accesses</i>	A.Deleted >> # A.Modified >> B.Modified B.Deleted >> A.Dangled B.Modified >> A.Modified	Generally, A is a behavioral concept accessing data object B To maintain integrity of model, B <b>may</b> need to be modified Signal to enterprise architect to adjust model The way A accesses B <b>may</b> need to be modified
<i>assignedTo</i>	A.Deleted/Modified >> B.Dangled B.Deleted >> # B.Modified >> A.Modified	Deleting/modifying A may result in dangled B, for which enterprise architect needs to be signaled
<i>usedBy</i>	A.Deleted >> B.Dangled A.Modified >> B.Modified B.Deleted >> # B.Modified >> A.Modified	B is generally declared to the environment. If A is deleted, B cannot use it anymore; A should be replaced by something that will satisfy B's requirement
<i>realises</i>	<b>A.Deleted &gt;&gt; B.Deleted</b> A.Modified >> B.Modified B.Deleted >> # B.Modified >> A.Modified	B is generally a logical entity while a concrete entity A realizes it
<i>triggers</i>	A.Modified/B.Modified >> # A.Deleted >> B.Dangled B.Deleted >> #	Since B starts <i>after</i> A, they are isolated and changes in either do not affect the other If after deleting A, there is no trigger left for B, enterprise architect needs to be signaled
<i>composedOf</i>	<b>A.Deleted &gt;&gt; B.Deleted</b> A.Modified >> B.Modified B.Deleted >> A.Modified B.Modified >> A.Modified	B cannot exist without A A's modification may need modifying B; similarly change in B may require change in A

>> - Implies, # - Don't Care

Figure 15 Heuristic Rules Capturing Change in EA (Sunkle et al., 2013)

### Cost analysis

Most of the techniques used for project cost analysis incorporates some financial calculation in order to evaluate the economic return value of an investment or a project. This includes Net Present Value (NPV), Internal Rate of Return (IRR), Return on Original Investment (ROI), Return on Average Investment (RAI), Payback Period (PP), and Expected Value (EV). A 1991 industry survey of the use of the above techniques indicated a movement towards the use of NPV, a moderate reduction in the use of IRR, and a significant decrease in the use of PBP when compared to a 1978 survey (Archer & Ghasemzadeh, 1999).

Previous researches have also demonstrated the use of ArchiMate model or enterprise architecture for cost analysis in an organization. The most notable one is from a paper by M. E. Iacob et al. (2012), in which they considered cost as part of valuation aspects in business strategy and modelled it with ArchiMate. In other related paper, a bottom-up approach for cost calculation in service-based enterprise architecture models was presented using the Archimate language (M.-E. Iacob & Jonkers, 2006). Furthermore, Quartel et al. (2010) in their paper also presented an approach for IT portfolio valuation that uses enterprise architecture extended with business requirements modelling as a basis for the analysis.

### Risk analysis

Depending on the different knowledge areas, several definitions of risk can be found in the literature. For instance, in software engineering, risk is defined as an undesirable outcome that poses a threat to the achievement of some objective (Sommerville, 2010).

Similarly, Barateiro et al. (2012) also argued in their paper that a risk exists when a threat with the potential to cause loss or harm occurs and is able to exploit a vulnerability/weakness associated with an asset that has a value to be protected. The type of assets depends on the nature of the organization, but might include physical entities (e.g., person, office), information entities and processes.

Moreover, risk management has been designated as one of the eight main areas of the Project Management Body of Knowledge (PMBOK) by the Project Management Institute, which is the largest professional organization dedicated to the project management field (Raz & Michael, 2001). Thus, it is not surprising that there are many risk management frameworks and methodologies existed in the literature. Usually, the risk management process is characterized by the combination of policies and procedures applied to the activities of establishing the context, assessing (identifying, analyzing and evaluating), treating, communicating, consulting, monitoring and reviewing the risks (Barateiro et al., 2012). The summary of the common risk management process is depicted in Figure 16 below.

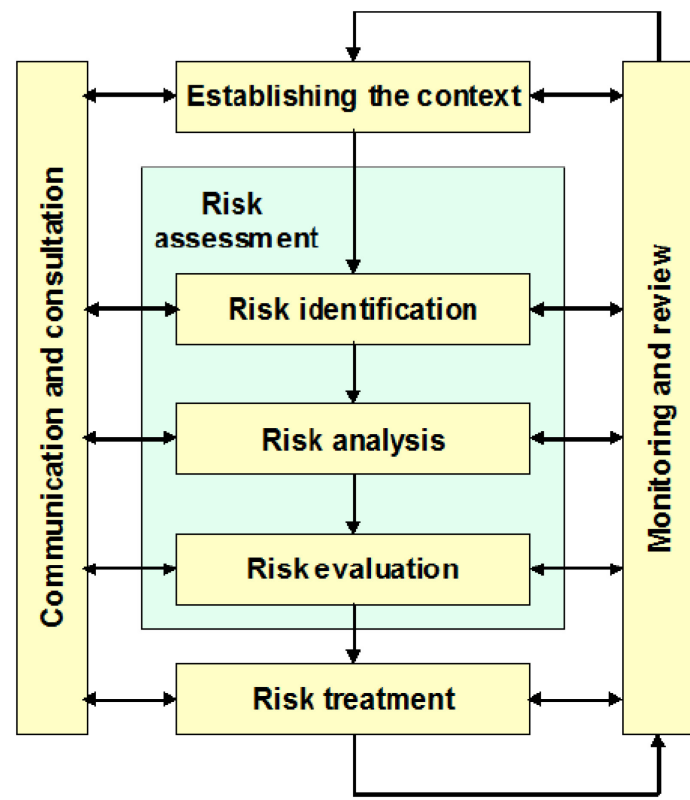


Figure 16 Risk Management Process (Barateiro et al., 2012)

With regards to EA-based analysis for risk assessment, The Open Group (2009) provides a definition and taxonomy for information security risk, as well as information regarding how to use the taxonomy. It describes the main factors that drive risk, their definitions, and relationships, so it provides a guideline for defining the basic terms for defining and measuring risk using a single logical and rational taxonomical framework. Then, in the white paper by Band et al. (2015), they provided analysis of the possible approaches to modelling risk and

security concept in ArchiMate language through concept mapping and case studies. The summary of the main mapping of the concepts is depicted in Figure 17 below.

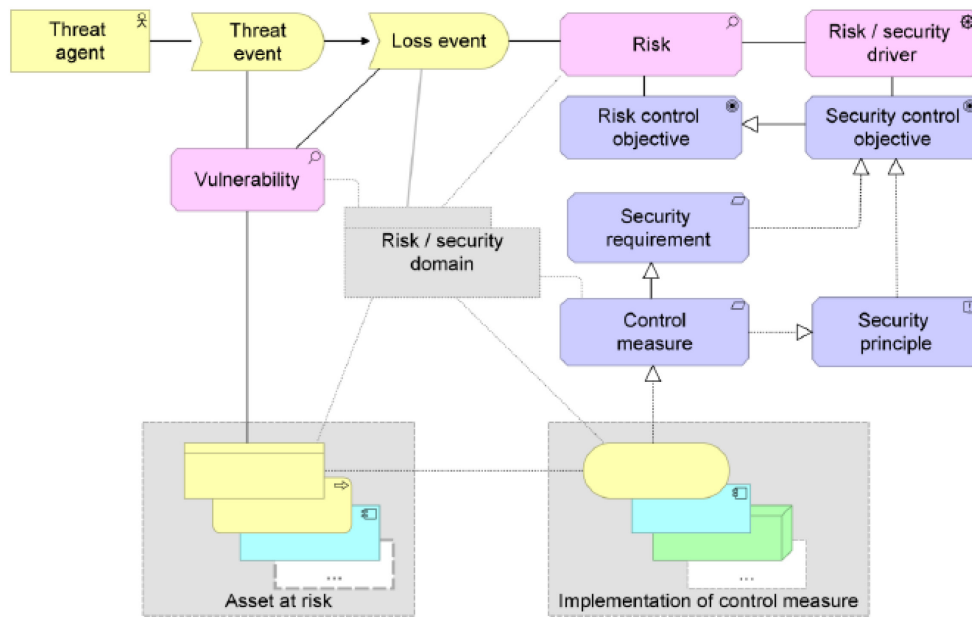


Figure 17 Risk and Security Concepts to Archimate Language (Band et al., 2015)

## 3 Multi-Criteria and Model-Based Analysis of Project Selection Method

In this chapter, the proposed project selection method using model-based analysis is explained. Firstly, a brief introduction and overview of the method is described in Section 3.1. Then, detail explanation about the steps required for the method will be described in the following sections. At the end of the chapter, the result of the method is discussed along with summary of the proposed method.

### 3.1 Model-Based Project Selection Method

The goal of this research is to develop an analysis method that integrates the concept of capability based planning and project portfolio management, which can help organizations to achieve their strategic objectives and achieve better strategic alignment. This approach should guide an organization through a comprehensive project selection process based on capabilities, which is expected to help organizations to manage their capabilities and project portfolio better.

As already explained in the previous chapter, the concept of capability-based planning and project portfolio management are interrelated with one another. In summary, Capability-Based Planning can use information from the Strategic Management domain to determine what capabilities are important in order to realize the strategic objectives of the organization. The information from capability-based planning might be useful in the Project Portfolio Management domain to help prioritizing on which capabilities the investments should be made first, considering some constraints for example on budget and time. On the other hand, projects are also important in capability-based planning as a way to realize capability improvement or increment.

However, realization of capability increment is not the only constraint when selecting or prioritizing projects in an organization. There are also other general constraints such as the project cost, available resources, implementation time, monetary benefit, project risk, etc. Thus, the main objective of the proposed method is to incorporate the goal of realizing needed capability increment with other important constraints in project selection process. With this in mind, the expected outcome of the method is the optimal project ranking based on the mentioned criterion and constraints. A summary of flowchart for the proposed project selection method modelled with BPMN is shown in Figure 18.

As can be seen in the figure, the method combines capability analysis using AHP method with individual project analysis as the criteria to perform the final project selection analysis. Enterprise architecture -based modelling is also incorporated in the proposed method as the technique to conduct individual project evaluation. The motivation behind this is explained in Section 3.3.

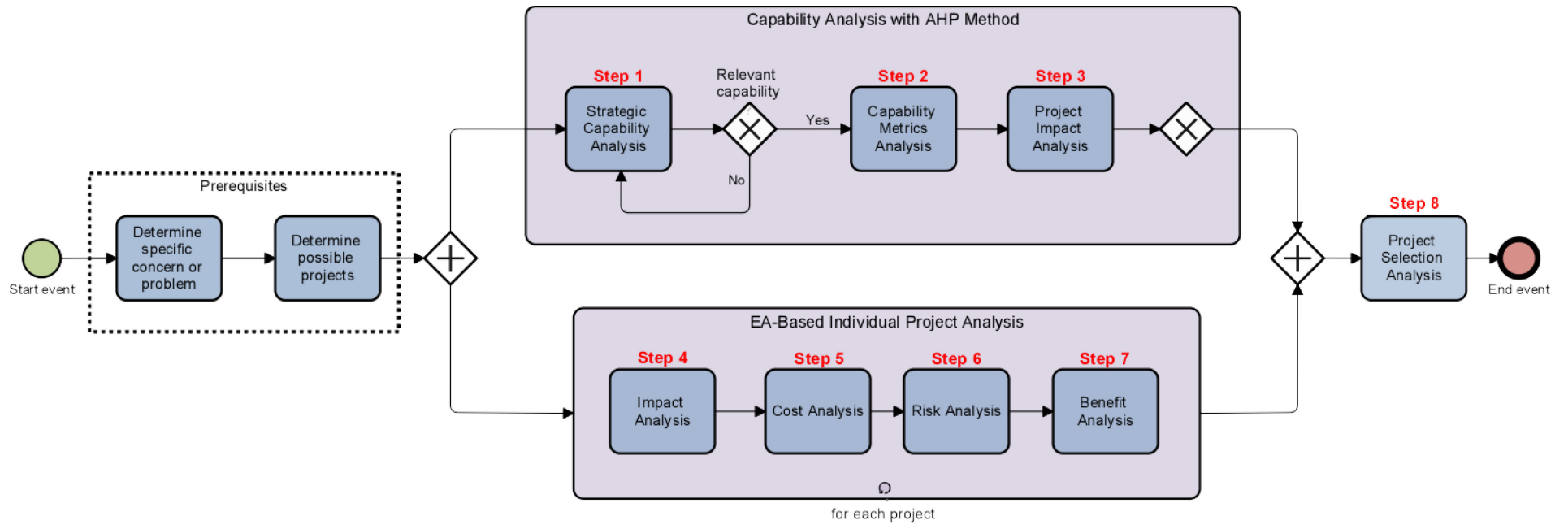


Figure 18 Proposed Project Selection Method

For each step in the method, available techniques that can be used will be also provided along with examples on how to use the technique for the analysis. Besides, a summary of each step in the method will be explained in the beginning of each sub-section. This includes the goal of each step, input, output, and available techniques to conduct the step. In addition, ArchiMate models will be illustrated for each step in the method. These models were made based on the EA tools available in BiZZdesign, namely the Enterprise Studio.

### 3.2 Analysis with AHP Method

This section of the chapter describes the steps in the method that is performed using the help of the AHP method. The AHP method has been explained briefly in Chapter 2, but in summary, the process in analysis using the AHP method consists of four basic steps. First is structuring the problem as a hierarchy, pairwise comparisons among the elements of adjacent hierarchy levels, combining the pairwise comparisons to derive weights for hierarchical elements, and lastly synthesizing the element weights into a set of ratings for decision alternatives.

In the AHP method, structuring the problem involves breaking the problem down into its component parts and arranging them into a hierarchy according to a set of specific guidelines. Most decisions can be broken down into a goal, a set of criteria, and a set of alternative actions. The goal consists of a concise statement of the purpose of the decision. The set of criteria consists of all considerations that should be satisfied to meet the goal. By convention, criteria are stated positively. More general criteria can be divided into progressively more focused sub-criteria as required by the problem at hand. The set of alternatives consists of different actions that can be taken to achieve the goal. To avoid problems with double counting, each alternative must be unique with respect to the others.

Thorough explanation on how to use the AHP for the proposed method is presented in the next section. Firstly, capability analysis is explained in 1.2.1. Next, capability metrics analysis and project impact analysis will be described in 1.2.2. and 1.2.3, respectively.

#### 3.2.1 Step 1: Strategic Capability Analysis

In the first part of the method, the focus is mainly on capability analysis based on a specific concern or problem in the organization. It is assumed that the organization already has a good understanding of their capabilities and how it can achieve their objectives in order to realize the high-level goals to maintain its competitive advantage. Thus, a capability map of the organization is the most important input for this step. Beside the capability map, it is also necessary to have the related concerns or problems faced by the organization which needs to be addressed immediately. In this scenario, the high-level goal is to select a project that has the highest chance of solving the problem faced by the organization. Other possible scenario could be the organization has a new strategic shift and thus must address this new strategy and translate it into projects that will realize the shift. In this second scenario, the strategic objectives derived from strategy map and balance scorecard could be used as the inputs for this step, as can be seen in Table 8.

Moreover, it is better if the organization know the performance of each capability, since it can be used as an input to analyze which capability is relevant for a specific concern. Cheng (2015) in her thesis presented detail steps on how to assess capability using the capability assessment framework and capability performance level. The result of capability assessment can be presented using capability heat map (Aldea, 2017; Cheng, 2015), as also explained in the previous chapter.

Table 8 Summary of Step 1

<b>Step 1: Capability Analysis</b>		
<b>Objective</b>	To select which capabilities are important to solve certain problem in the organization	
<b>Input</b>	Concern-Based Scenario	Strategic Shift Scenario
	<ul style="list-style-type: none"> <li>- Capability Map</li> <li>- Capability Assessment Result/ Heat Map</li> <li>- Concerns/ problems</li> <li>- Assessments related to problems</li> </ul>	<ul style="list-style-type: none"> <li>- Capability Map</li> <li>- Capability Assessment Result/ Heat Map</li> <li>- Strategy Map</li> <li>- Balanced Scorecard</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Determine the problem to be solved</li> <li>- Determine the assessments related to problem</li> <li>- Determine related or relevant capabilities</li> <li>- Structure the problem (AHP)</li> <li>- Conduct pairwise comparison (AHP)</li> <li>- Calculate priority result (AHP)</li> <li>- Check consistency of the result (AHP)</li> </ul>	
<b>Techniques</b>	<ul style="list-style-type: none"> <li>- AHP</li> <li>- Workshops</li> </ul>	
<b>Output</b>	<ul style="list-style-type: none"> <li>- Strategic or Relevant Capability</li> </ul>	

For this step, AHP is used to analyze which capability contributes the most to a specific problem or driver based on some defined criteria. It can be used for both aforementioned scenarios, either addressing a problem faced by the organization or realizing a strategic shift in an organization. Firstly, the problem must be structured based on the problem and the result of assessment related to the specified problem. An example of a problem structure is depicted in Figure 19 below.



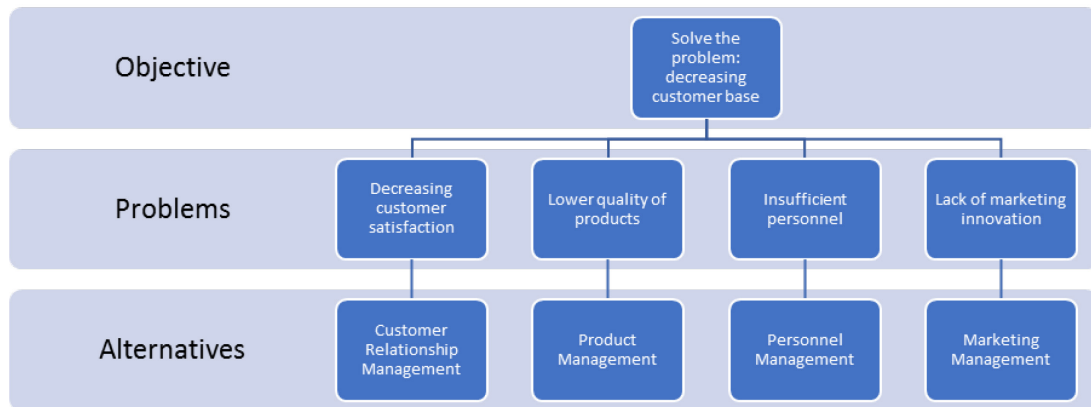


Figure 19 Example of Problem Structuring in AHP

Then, pairwise comparison of the assessments is calculated to analyze which assessment has more impact on the problem. After that, for each assessment, priority calculation of the relevant capabilities is executed. The result of the AHP method will represent the ranking of the capabilities according to its impact on the problem based on the specified assessments in the problem structure. Figure 20 below shows an example capability analysis result modelled with ArchiMate using the color-code techniques to visualize the AHP result. The detail steps of the AHP calculation is presented in Appendix 3.

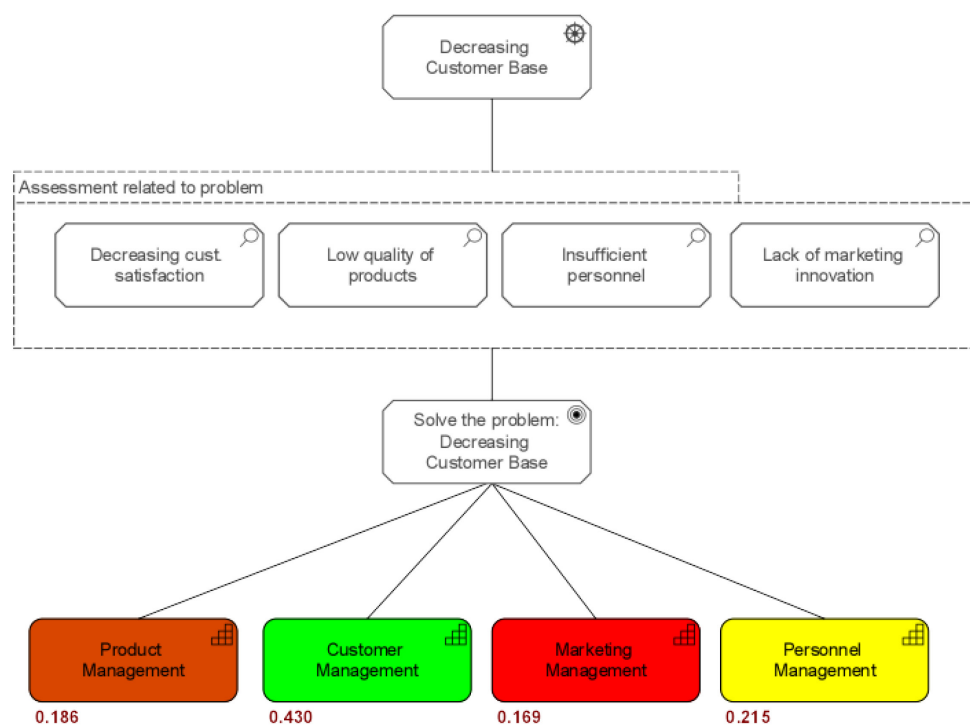


Figure 20 Modelling Capability Analysis

The result of the AHP method above shows that Customer Management capability has the highest impact to solve the problem based on the assessments defined. Thus, it can be concluded that the organization should focus on improving this capability to address the decreasing customer base issue. Moreover, choosing a project that could realize the

improvement of Customer Management capability is crucial and must be used as one of the criteria in selecting projects to address this specific problem.

It is important to note that the AHP score for ‘Customer Management’ capability is relatively higher than the rest of capabilities. However, it is of course possible to have more than one capability that scores high, which means they have a big impact on the specified concern. There are two possible ways of choosing which capability should be selected for the next step based on the score of the AHP. First, if the AHP score for a capability is higher than the average, then it should be considered as criteria for project selection. Secondly, if the AHP score for a capability has a value higher than  $1/n$  ( $n$ = the number of selected capabilities) then this capability can be considered as the relevant capability for the concern. In this case, since there are four relevant capabilities, any capabilities that have a score higher than 0.25 must be selected as criteria for the final selection. Consequently, for this case, ‘Customer Management’ capability is chosen. However, in case there are more capabilities (more than five), it is also advised to only select at maximum three relevant capabilities that have the highest score from the AHP calculation. This is important to ensure that only relevant capabilities that have a direct impact to the concern are considered while the rest could be omitted. Thus, the focus of the analysis will remain on the specific concern or problem that organizations have.

To sum up, this analysis technique is supposed to help the organization in choosing the relevant or significant capability based on a specific concern, or a new strategy defined. The result of this analysis will be used in the next step to determine if the possible projects have a positive impact on the improvement of the capability.

### 3.2.2 Step 2: Capability Metrics Analysis

The objective of this step is to specify the relevant capability metrics that are considered crucial for the chosen capability from the previous step and determine the associated weights based on the importance of each metric. The activities necessary to be performed to determine the weights for capability metrics are shown in Table 8. For this example, it is assumed that there is only one significant capability as the result of the previous step.

*Table 9 Summary of Step 2*

<b>Step 2: Capability Metrics Analysis</b>	
<b>Objective</b>	To determine relevant capability metrics for a specific capability and ranking of these metrics with regards to the improvement of capabilities to solve the problem
<b>Input</b>	Selected relevant capability (from Step 1)
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Determine metrics or KPIs for a specific capability (result from Step 1)</li> <li>- Conduct pairwise comparison (AHP)</li> <li>- Calculate priority result (AHP)</li> </ul>

	- Determine weighted scores for capability metrics (AHP)
<b>Techniques</b>	AHP Method
<b>Output</b>	Weights of Capability Metrics

The first activity for this step is to determine relevant metrics for the selected capability. Defining capability metrics is crucial for the organization to have an objective look at the outcomes of improving a capability, and also it can help with assessing the current and desired capability performance levels, with monitoring progress, and with evaluating the realized outcomes of the improvement (Aldea, 2017; Taylor, 2005). A spider chart can be used to represent the gap between current and target capability level based on capability metrics as also explained in the study of Aldea (2017). However, this will only show the current and desired performance of a capability based on its metrics without showing the importance level of each metric. This is the reason why the AHP method is used. If we understand which metrics are important for a particular concern, then project impact on the capability could be assessed based on this information.

To illustrate the activities to be performed, the result of the previous step will be used as an example. Firstly, relevant capability metrics for 'Customer Management' capability need to be defined. It is important to also keep in mind the high-level concern or problem that wants to be addressed when determining the capability metrics. In this example, the metrics selected for customer management capability are response time, waiting time, customer retention rate, and customer acquisition cost. Then, AHP method is used to prioritize these metrics based on the importance level to solve the problem faced by the organization. The calculation of the AHP is explained in Appendix 4, while the result of the calculation for this step is presented in Figure 21 below.

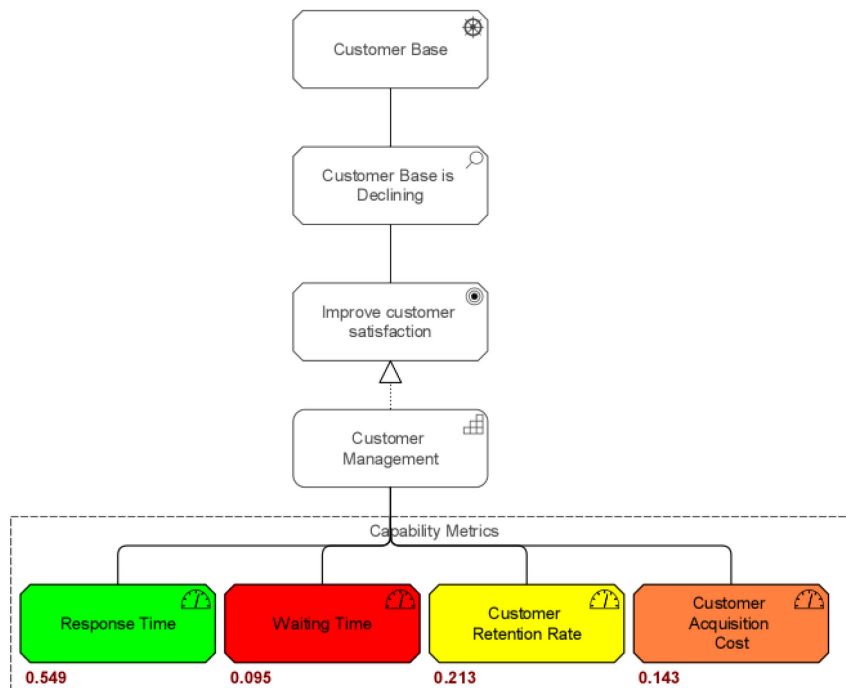


Figure 21 Capability Metrics Analysis, modelled with ArchiMate

The result can be interpreted based on the AHP score for each metric. High score for a capability metric means that this metric is considered to be important compared to other metrics for capability improvement to solve the defined problem. In this case, response time has the highest score from the AHP method. This result means that in order to solve the problem of declining customer base, response time to the customer must be increased. This implies that when selecting a project or an investment, to acknowledge that the selected project must have an impact on the response time to customer. The weights for the capability metrics derived from the calculation of the AHP method will be used as inputs for the next step.

### 3.2.3 Step 3: Project Impact Analysis

The objective of this step is to choose which projects can realize the increment of a particular capability based on its capability metrics. As explained in Chapter 2, a capability increment is a version of a capability that represents as an increase in the performance of the capability (Aldea, 2017). In EA point of view, each capability increment can be realized by a specific plateau or a state in the architecture that represents a stage in the evolution of the capability (The Open Group, 2016).

The result of the AHP method from previous step will be used as the inputs for this analysis, which will also use AHP method. In summary, it is a problem with two level hierarchy that can be analyzed together using AHP method. For the sake of clarity, these two levels in the AHP method are identified as different steps for the proposed method in this research. A brief summary of this step is presented in the table below.

Table 10 Summary of Step 3

<b>Step 3: Project Impact Analysis</b>	
<b>Objective</b>	To determine which projects has the biggest impact on the capability improvement based on its metrics
<b>Inputs</b>	<ul style="list-style-type: none"> <li>- Project options and project data</li> <li>- Capability metrics and its ranking score (from Step 2)</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Determine possible projects and collect project data</li> <li>- Conduct pairwise comparison (AHP)</li> <li>- Calculate priority result (AHP)</li> <li>- Determine project score (AHP)</li> </ul>
<b>Analysis Techniques</b>	AHP method
<b>Output</b>	Score of each project with regards to its impact on the capability based on capability metrics

For this step, the data possible projects that want to be analyzed must be populated in order to evaluate its impact on the capability metrics. For example, there are three possible projects that need to be evaluated to solve the problem of decreasing customer base, as depicted in Figure 22 below. Using the AHP method, prioritization of the projects with regards to the metrics can be done by the decision makers. Once it is completed, the results are combined and calculated to determine the final result of the AHP method. Detail calculation of this two-level hierarchy problem (combination of Step 2 and Step 3) using the AHP method is presented in Appendix 4. The final result of this calculation is shown in Figure 22.

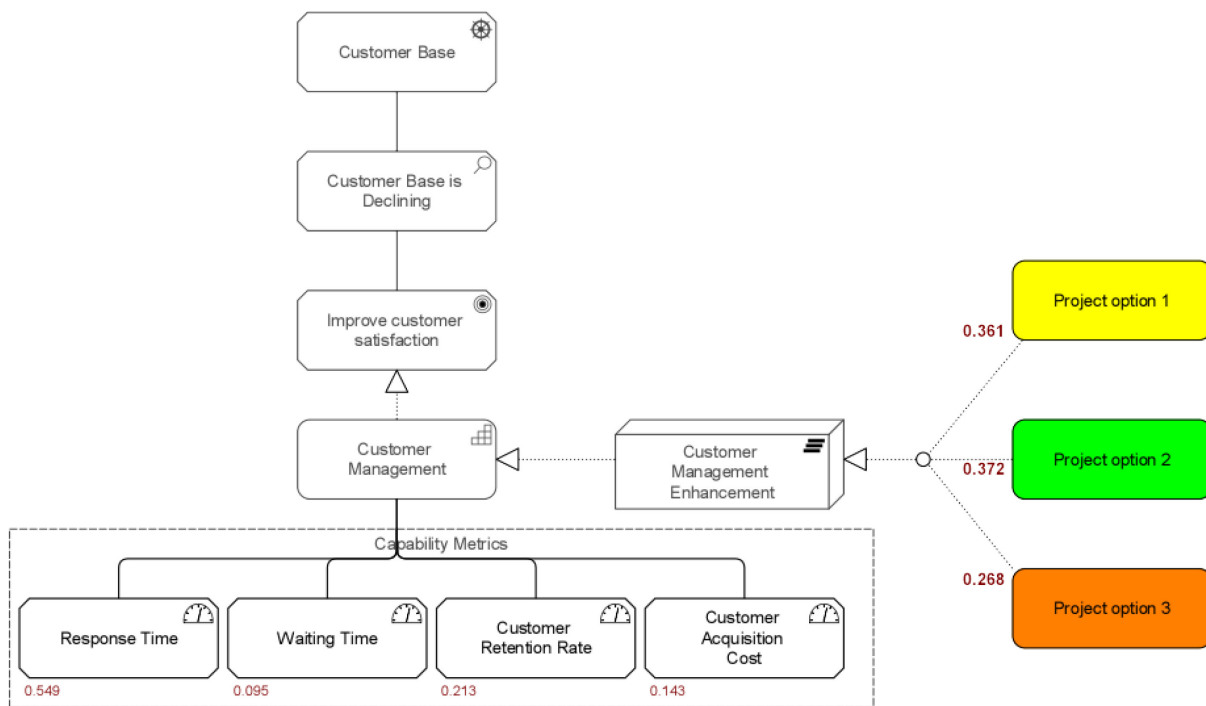


Figure 22 Result of the AHP, modelled with ArchiMate

The result above indicated that the score for each metric (result of Step 2) influences the final score for each project, which is a result of solving a two-level hierarchy problem with AHP method. On the other hand, the score for each possible project, or the final score, represents the impact of each project on the improvement of 'Customer Management' capability with regards to its capability metrics. In this example, project 2 has the highest score in the final calculation. This result indicated that project 2 has the biggest impact on the improvement of Customer Management Capability based on the specified metrics. To sum up, these scores on the impact of the possible projects on capability improvement will be used as input for project selection process. This will be explained in more detail in Section 3.4.

### 3.3 Enterprise Architecture-Based Analysis

In the previous section, it is already argued that the result of capability analysis is crucial in selecting projects in project portfolio management. However, there are also other criteria to be considered in a project selection process. Asosheh et al. (2010) presented a summary of project selection criteria used in previous studies, as depicted in Table 11 below. As can be seen in the table, cost is amongst the most important criteria mentioned in the literature. Other than that, benefit or profitability, risk, and completion time are also notably cited in the previous studies.

Table 11 Criteria in previous studies (Asosheh et al., 2010)

Author(s)	Criteria in project selection
Badri et al. (2001)	Risk, completion time required, training time required, annual cost of additional manpower, decision-makers preferences, user's preferences, benefit, hardware cost, software cost, other cost

<b>Lee and Kim (2001)</b>	Program hours, analyst hours, hardware cost, clerical labor hours, benefit
<b>Wen et al. (2003)</b>	Profitability, capital utilization, capacities, e-commerce site quality, web technology investment, corporate operating cost, number of e-commerce staff
<b>Santhanam and Kyparisis (1995)</b>	Benefits, hardware cost, software cost, other cost, risk score
<b>Sowlati et al. (2005)</b>	Green dollar costs, brown dollar cost, level of urgency, potential risk, green dollar benefits, brown dollar costs, breath of benefits, intangible benefits
<b>Mahmudi et al. (2008)</b>	Software cost, training cost, support cost, potential risk, time reduction, system accuracy, improvement management capabilities

In order to provide a complete guideline on project selection process, analysis on these criteria will also be presented in this research. This include cost analysis, risk analysis, and benefit analysis. The analysis will be based on the enterprise architecture using model-based analysis. The motivation of using EA for the analysis is because model-based analysis plays a central role whenever a change in the enterprise architecture is needed or performed (Lankhorst et al., 2013). In this case, possible projects to be implemented will have some impact on the enterprise architecture, usually depicted in the target architecture. This impact will be the basis for the model-based analysis to determine cost, risk, and benefit score of each project.

Thus, impact analysis for each project will need to be performed first. This will be explained in detail in section 3.3.1. After that, the remaining of the analysis will be performed. Explanation on the cost analysis is provided in section 3.3.2. Lastly, risk analysis and benefit analysis will be described in section 3.3.3 and 3.3.4, respectively.

### 3.3.1 Step 4: Impact Analysis

There are many definitions of impact analysis, depending on its usage in various fields such as software management, change management, project management, or in the field of strategic management. Impact analysis is the activity of identifying what to modify to accomplish a change, or of identifying the potential consequences of a change (Arnold, Robert S., 1996). In this case, the impact analysis is used to evaluate planned impacts of a project as a changing activity.

Impact analysis, which determines the effects of changes or failures on other architectural elements, can therefore provide valuable information for enterprise architects. Whether an element is affected depends on its context, which is the connections to other elements and their semantics with respect to the analysis. Consequently, change impact analysis for EA is concerned with computing the effects of change in any part of an enterprise on the rest of the enterprise (Sunkle et al., 2013).

The techniques available for impact analysis varies from quantitative impact analysis to argumentative or qualitative analysis. In addition, several attempts have been made in

conducting change impact analysis based on the enterprise architecture, such as research by Langermeier et al. (2014) and Sunkle et al. (2013). Detail explanation of this research is provided in the theoretical background as part of Chapter 2.

In the case of this research, impact analysis stimulates the effects of the changes derived by a project in order to assess risks, cost, and benefits in the architecture. It is important to note that the change usually is more than just one change in one architectural element. Thus, applying such propagation or heuristic rules might be complicated in most of the cases. However, the different types of impact as a result of a change presented in both papers are still applicable to be used for analyzing the impact of a project in the architecture. In addition to the types of changes defined in the paper by Langermeier et al. (2014) and Sunkle et al. (2013), we also supplement the types with ‘addition’. To sum up, the types of changes that will be used in the impact analysis for project is illustrated in the table below.

*Table 12 Possible Types of Changes in Impact Analysis*

Possible types of changes	Reference(s)
<b>Deleted</b>	(Langermeier et al., 2014; Sunkle et al., 2013)
<b>Modified</b>	(Langermeier et al., 2014; Sunkle et al., 2013)
<b>Extended</b>	(Langermeier et al., 2014)
<b>Added</b>	No reference
<b>No change</b>	(Langermeier et al., 2014; Sunkle et al., 2013)

To be able to perform impact analysis, it is important for the enterprise architects to have an understanding of both the ‘As-is’ and ‘To-be’ architectures, as shown as one of the activities in Table 13 below. The ‘As-is’ architecture represents how IT supports the business operations in the current situation, and indirectly, the strategic business goals. In contrast, projects are developed and executed to design and realize a ‘To-be’ architecture that represents a future (desired) situation in which IT support is improved (Quartel et al., 2010).

*Table 13 Summary of Step 4*

<b>Step 4: Impact Analysis</b>	
<b>Objective</b>	To detect the change impact derived by a project on the architecture of the organization
<b>Inputs</b>	<ul style="list-style-type: none"> <li>- Current state architecture</li> <li>- Future architecture</li> <li>- Project data or information</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Gather project data or information</li> <li>- Determine the current (as-is) architecture relevant to the project</li> <li>- Develop the planned (to-be) architecture of the project</li> <li>- Determine or detect the changes required from the current architecture to realize the planned future architecture</li> </ul>



	<ul style="list-style-type: none"> <li>- Determine the level of the impact for each change required in the architecture (delete, add, modify, extend, or no change)</li> <li>- Model with ArchiMate</li> </ul>
<b>Techniques</b>	<ul style="list-style-type: none"> <li>- EA-based impact analysis</li> <li>- Data flow analysis technique</li> <li>- Cost benefit analysis</li> </ul>
<b>Output</b>	<ul style="list-style-type: none"> <li>- Gap Analysis</li> <li>- Change Impact Analysis</li> </ul>

After that, changes required to realize the 'To-be' architecture can be detected using project data information. The level of impact is represented by the types of changes occurred in each architectural element. Lastly, these impacts and changes can be modelled in ArchiMate using color-coding techniques. The impact analysis result can be marked as per the color code to represent the type of changes occurred in the EA elements. In addition, business impact level could be applied to represent how strong or weak the impact is to with regards to the architecture. Example of how to model impact analysis in ArchiMate is presented in Figure 23 below.

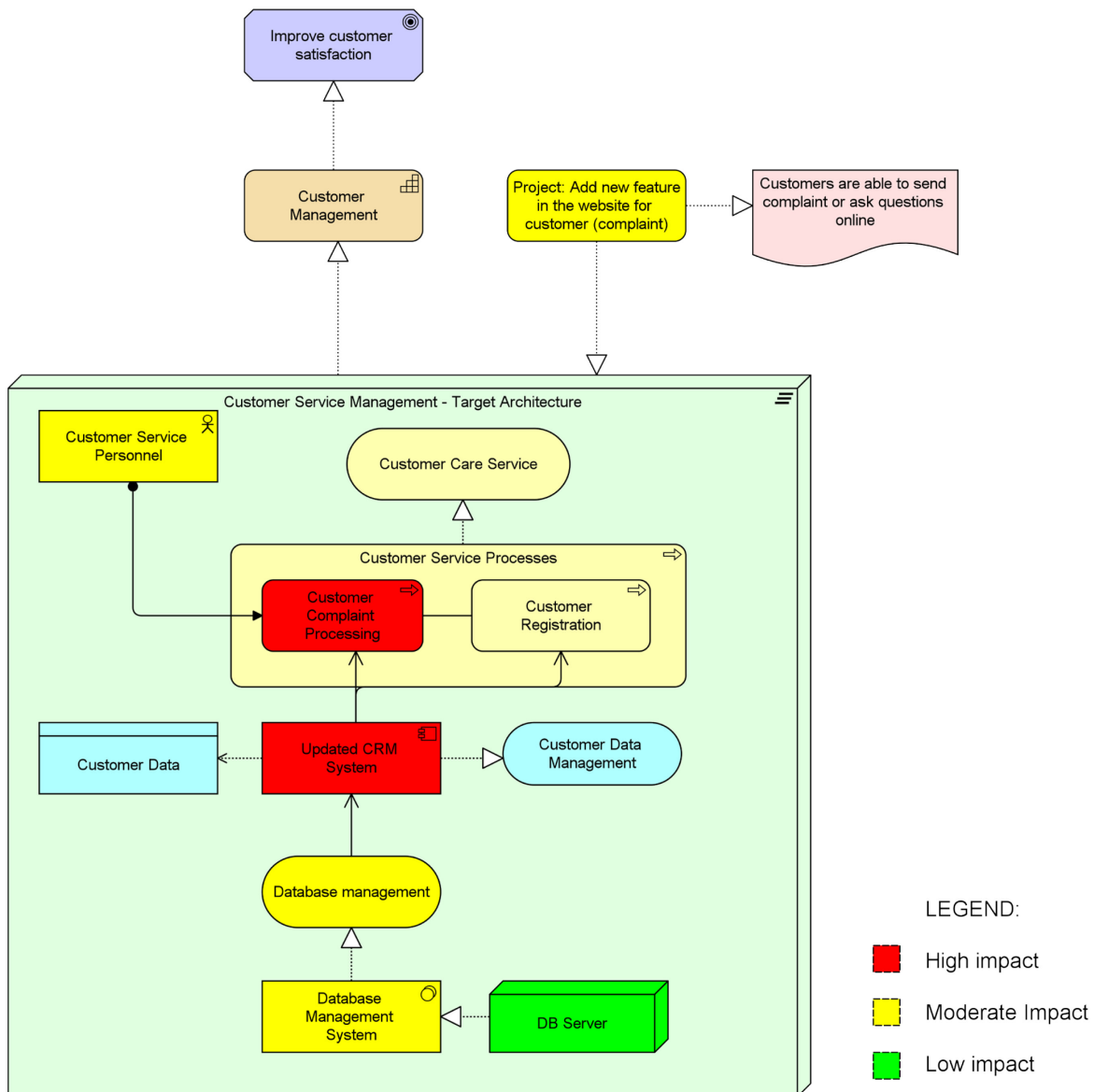


Figure 23 Modelling Impact Analysis with ArchiMate

For the example in the figure above, the CRM system is updated. Thus, any elements that are associated with this element could be impacted by this update. As can be seen in the figure, the 'Customer Complaint Processing' element is highly impacted, since the CRM System serves this process. Therefore, it is marked with red color to represent the level of impact in the architecture. On the other hand, some elements will have moderate impact to the change occurred in the CRM system. This includes additional personnel to handle complaint processing, database management, and extended system for the database. In the example above, the element of the database server, marked with green color, will only have low impact associated with the updated CRM system. The rest of the elements are assumed to have no direct impact from the changes in the architecture.

### 3.3.2 Step 5: Cost Analysis

Cost analysis is the next step in the EA-based analysis phase. It can be explained as a procedure for estimating all costs involved from a business opportunity or proposal, and in this case, from a project. The cost itself, is defined as a type of value which has quantitative definitions, mostly expressed in monetary measures. It represents the quantity of a certain resource needed for a project or activity (Iacob, Quartel, et al., 2012).

Most of the techniques used for project cost analysis incorporates some financial calculation in order to evaluate the economic return value of an investment or a project, as already explained in the previous chapter. In addition, several papers have also demonstrated the use of ArchiMate model or enterprise architecture for cost analysis in an organization. The most notable one is from a paper by Iacob, Quartel, et al. (2012), in which they considered cost as part of valuation aspects in business strategy and modelled it with ArchiMate. In other related paper, a bottom-up approach for cost calculation in service-based enterprise architecture models was presented using the ArchiMate language (Iacob & Jonkers, 2006). Furthermore, Quartel et al. (2010) in their paper presented an approach for IT portfolio valuation that uses enterprise architecture extended with business requirements modelling as a basis.

Table 14 Summary of Step 5

Step 5 - Cost Analysis	
<b>Objective</b>	To determine the approximate cost of the possible projects
<b>Inputs</b>	<ul style="list-style-type: none"> <li>- Change Impact Analysis</li> <li>- Project Data</li> <li>- Historical Data for cost estimation</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Prepare the result of impact analysis</li> <li>- For each change or impacted nodes in the architecture, determine the associated cost based on the type of the change in the architecture</li> <li>- Repeat steps for the next change</li> <li>- Finally, sum all the associated cost to determine project cost</li> <li>- Model with ArchiMate</li> </ul>
<b>Techniques</b>	<ul style="list-style-type: none"> <li>- EA-based analysis</li> <li>- Financial methods (NPV, ROI, PP, IRR)</li> <li>- Cost Benefit Analysis Method (CBAM)</li> </ul>
<b>Output</b>	<ul style="list-style-type: none"> <li>- Estimation of Expected Project Cost</li> </ul>

In this research, we proposed an approach to estimate project cost based on enterprise architecture. The main idea is to determine cost based on the changes in the enterprise architecture, which is the result of the impact analysis from previous step. The result from the impact analysis will be used to determine which of the elements in the architecture will

generate costs, as described in the activities in Table 14. It is assumed that any impacted elements in the architecture might have the chance to have some costs associated with it. Thus, the starting point of this analysis is the result of the impact analysis from previous step. Then, the next step is to determine all the nodes that will generate costs, along with what kind of costs might be associated with it. The last step is to model the cost analysis in ArchiMate. Based on Iacob, Quartel, et al. (2012) in their paper, cost is a property that practically can be associated with any architectural entity and/or a specific project. Thus, when modelling cost with ArchiMate, cost can be defined as an attribute of any architecture element. An example of how to model cost analysis with ArchiMate is illustrated in Figure 24.

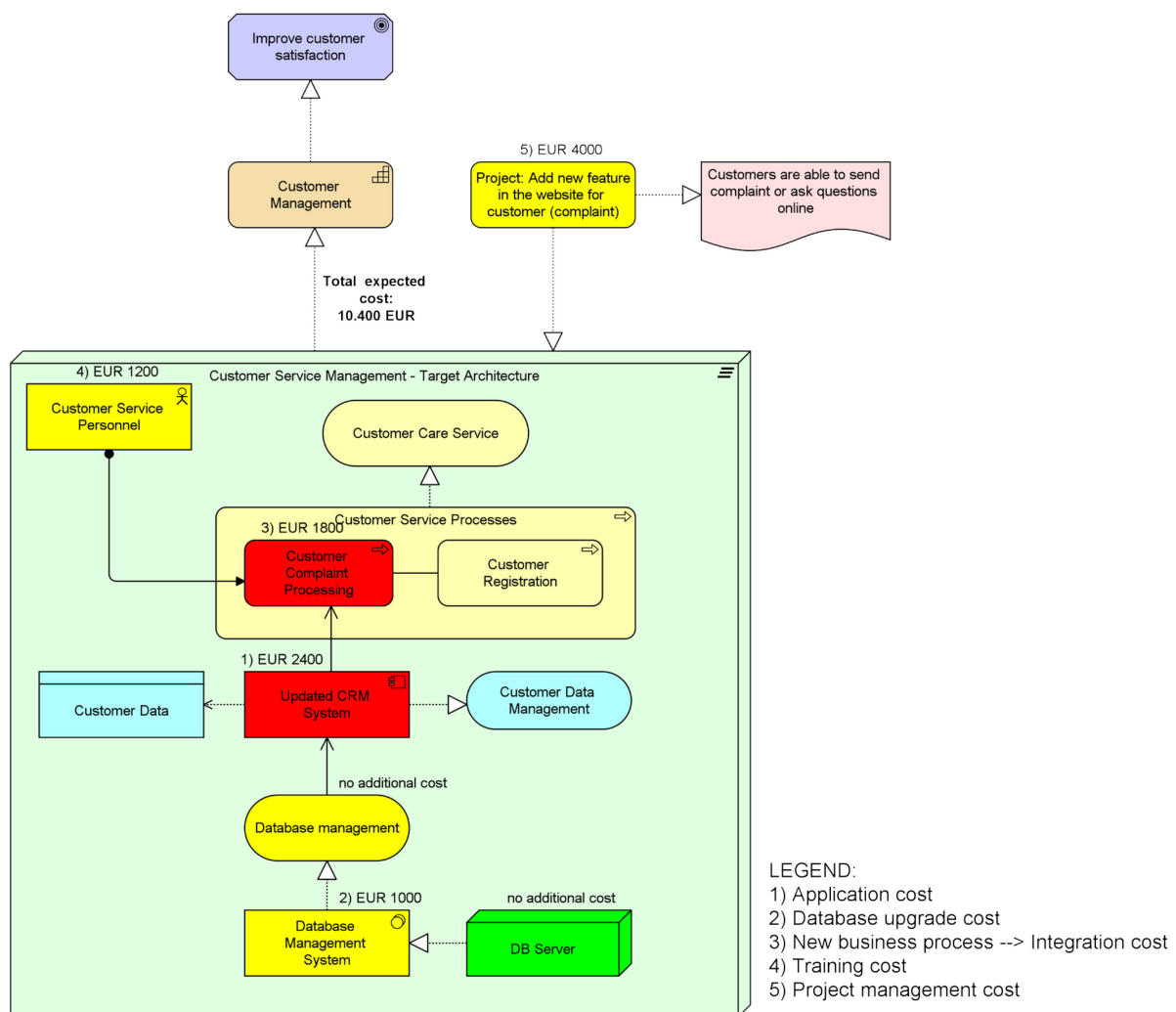


Figure 24 Cost Analysis modelled with ArchiMate

In the example above, each of the elements in the architecture will be analyzed further to determine the cost associated with the change impact defined in the previous step. Thus, each cost element is coupled with an element in the architecture that is possibly impacted by the change. Firstly, since the system is updated, additional application cost will be occurred. Additionally, since the database must be extended as well, the cost to upgrade the database must be added in the analysis. Integration cost is inevitable since there is a new business

process that must be integrated in the system. To handle this new business process, additional human resources is needed. It is assumed that this will be handled by existing personnel, which means only additional training cost will be counted in the analysis. Lastly, the change in the CRM system will be realized by a project, which means that project management cost must be also included in the analysis. Based on this EA-based analysis, the total expected cost for the project in the example above will be 10.400 euro.

### 3.3.3 Step 6: Risk Analysis

For this research, we used the definition risk defined by The Open Group (2009): “risk is the probable frequency and magnitude of loss that arises from a threat (whether human, animal, or natural event)”. Similarly, Barateiro et al. (2012) also argued in their paper that a risk exists when a threat with the potential to cause loss or harm occurs and is able to exploit a vulnerability/weakness associated with an asset that has a value to be protected. The type of assets depends on the nature of the organization, but might include physical entities (e.g., person, office), information entities and processes.

In Chapter 2, explanation about risk management process is provided in more detail. Basically, it usually includes the activities of establishing the context, assessing (identifying, analyzing and evaluating), treating, communicating, consulting, monitoring and reviewing the risks (Barateiro et al., 2012). From these, the main activities that will be applied for this research is establishing the context, risk identification, and risk analysis. The rest of the activities are considered as part of the project management area and should be done during the implementation of the project, thus will be excluded in this research.

In this case, the context is to assess the risks of the possible projects or investments. It is important to note that the risk identification and analysis are done prior to the project implementation. In order to do this, the risk assessment is conducted based on the changes in the architecture. The main idea is to determine the risk with regards to the architectural changes defined in the result of impact analysis in step 4 of the method, as described in the summary in Table 15.

Table 15 Summary of Step 6

Step 6 - Risk Analysis	
<b>Objective</b>	To determine the approximate cost of the possible projects
<b>Input</b>	<ul style="list-style-type: none"> <li>- Change Impact Analysis</li> <li>- Project Data</li> <li>- Cost Analysis</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Prepare the impact analysis (result of step 4)</li> <li>- Determine any events from the architecture that could possibly lead to value loss</li> <li>- Determine the possible risk and associated value loss</li> <li>- For each risk, define the level of impact and probability</li> </ul>


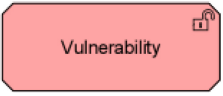
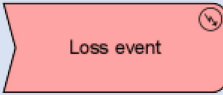
	<ul style="list-style-type: none"> <li>- Calculate the risk factor by multiplying impact and probability score (automatically calculated in Enterprise Studio)</li> <li>- Repeat if necessary (for other risks)</li> <li>- Determine total risk score for the project (the average risk score)</li> <li>- Model with ArchiMate</li> </ul>
<b>Analysis Techniques</b>	<ul style="list-style-type: none"> <li>- Scoring model</li> <li>- EA-based analysis</li> <li>- Risk heat map</li> <li>- Traffic lights techniques</li> </ul>
<b>Output</b>	<ul style="list-style-type: none"> <li>- Expected Project Risk</li> </ul>

For the calculation of risk, we used the most common risk calculation formula, which is the threat's probability multiplied with the magnitude of its effect (i.e., the size of the value loss). This is aligned with the risk taxonomy presented in Band et al. (2015) , in which "risk" is defined as the probable frequency and probable magnitude of future loss, which means that the risk definition is dependent on two factors: loss event frequency and probable loss magnitude.

In order to model risk, we use the guideline by The Open Group (2009) and Band et al. (2015) using ArchiMate as the main language. The detail explanation on this is presented in Chapter 2. In summary, they provided a definition and taxonomy for information security risk, as well as information regarding how to use the taxonomy along with possible approaches to modelling risk and security concept in ArchiMate language.

Based on the concept mapping described in Chapter 2, they argued that using the standard ArchiMate 2.1 language and defining new risk and security-specific specializations of ArchiMate 2.1 concepts are the most appropriate approaches that cover the majority of risk and security concepts (Band et al., 2015). This proposal was then realized in the ArchiMate 3.0 specification, as the next update of ArchiMate language (The Open Group, 2016). In this specification, the risk concept is not introduced as an independent concept, but rather as specialization of the assessment concept from the motivation extension, since it represents the outcome of some risk assessment. It is also important to note that the basis of these concepts is the consolidation of risk and security concepts, thus it is more applicable for security risks, which is more technical compared to project risks. However, some of the concepts are still relevant to be used for modelling project risks. Summary of these concepts is presented in Table 16.

Table 16 ArchiMate Concept used for Project Risk Modelling

Notation in ArchiMate	Concept	Parent Concept	Description
	Risk	Assessment	The probable frequency and probable magnitude of future loss.
	Vulnerability	Assessment	The probability that an asset will be unable to resist the actions of a threat agent.
	Loss Event	Business Event	Any circumstance that causes a loss or damage to an asset.

Risk calculation using ArchiMate is also supported in the Enterprise Studio tool by BiZZdesign. Traffic light rating is used to determine both the probability and the impact of risk. LEF (Loss Event Frequency) represents the probability of the risk to occur within a given timeframe. On the other hand, Probable Loss Magnitude (PLM) represents the impact of the risk. The Open Group (2009) presented a comprehensive guideline on how to assess both LEF and PLM in the context of security risks. However, in this research, rating or scoring of the impact and probability of risks will be used since it is more suitable for project risk assessment. The rating/scoring conversion along with the color code representation for impact and probability is presented in Table 17 below.

Table 17 Scoring Conversion for Impact and Probability

Impact		Probability	
<b>SV</b>	Severe impact	<b>VH</b>	Very high frequency
<b>H</b>	High impact	<b>H</b>	High frequency
<b>Sg</b>	Significant impact	<b>M</b>	Moderate frequency
<b>M</b>	Moderate impact	<b>L</b>	Low frequency
<b>L</b>	Low impact	<b>VL</b>	Very low frequency
<b>VL</b>	Very low impact		

It is also possible to assign and determine monetary value (e.g. minimum and maximum range) for the impact level and range of frequency for the probability level. However, these impact and probability range levels might vary based on the size of the organization so it could be decided based on the agreement between the relevant decision makers in the organization.

Once impact and probability are determined, risk factor can be calculated by multiplying the impact and the probability of each risk. In Enterprise Studio tool provided by BiZZdesign, the risk factor is automatically calculated based on impact and probability. Moreover, it is also automatically visualized using traffic light with different color codes. An example of modelling risk analysis using ArchiMate, with Enterprise Studio tool, is presented in Figure 25.

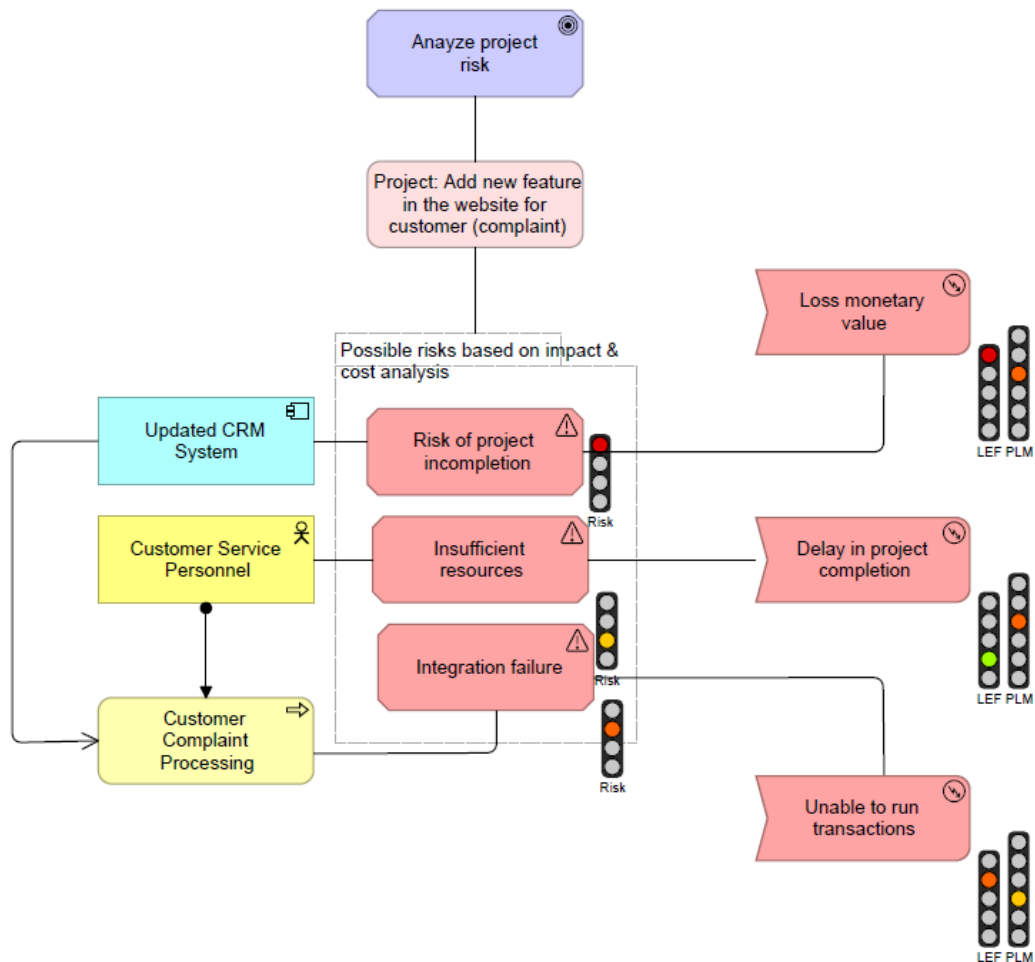


Figure 25 Modelling Risk with ArchiMate

The result of the project risk assessment could also be presented or visualized in a risk heat map. It is a valuable tool used to present summary of the risk in a higher level visually and in a meaningful and concise way. It can be automatically created using the value of frequency and magnitude of risk in the Enterprise Studio software, as depicted in Figure 26.



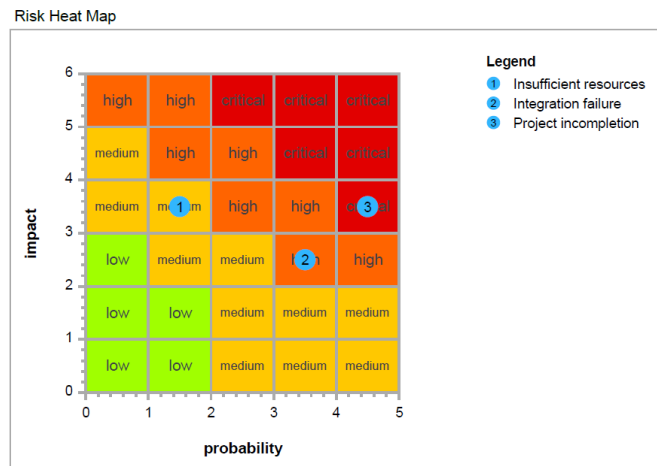


Figure 26 Risk Heat Map Example

The horizontal axis measures the impact of the risk, and the vertical axis measures the frequency or the probability of occurrence. The color represents the risk level and risk score, with pre-determined conversion, as also shown in the heat map in Figure 26. The risk level ranges from low to critical, and each level corresponds to a risk score ranging from 1 to 4.

Finally, final project risk score could be determined using the average of all risks identified based on the architecture, as described in the summary of this step presented in Table 15.

### 3.3.4 Step 7: Benefit Analysis

Benefit analysis is usually performed together with cost analysis as part of project evaluation method. By definition, a benefit is an outcome whose nature and value are considered advantageous by an organization (Sapountzis et al., 2009). In his book, (Bradley, 2016) also defines it as an outcome of change which is perceived as positive by a stakeholder. The important point in the above definitions is that benefits are owned by individuals or groups who want to obtain value from an investment (Sapountzis et al., 2009). In this case, the benefit to be analyzed are still in the form of 'expected benefit', which will be realized by the implementation of the project.

Since it is also part of project valuation method, financial calculation techniques are often used in a benefit analysis. However, measuring project benefit in monetary value is a challenging task, especially when it is only an estimation of a long-term and intangible benefit. Thus, in this method, benefit will be seen as an assessment of advantageous outcome that could be derived from a future project. As described before, the analysis will be performed based on architectural changes derived from the project as depicted in the result of impact analysis in step 4. Detail activities for model-based benefit analysis are listed in the summary below.

Table 18 Summary of Step 6

<b>Step 6 - Benefit Analysis</b>	
<b>Objective</b>	To determine the benefit of the possible projects
<b>Input</b>	<ul style="list-style-type: none"> <li>- Change Impact Analysis</li> <li>- Project Data</li> </ul>
<b>Activities</b>	<ul style="list-style-type: none"> <li>- Prepare the impact analysis</li> <li>- Determine any events from the architecture that could possibly lead to value gained</li> <li>- Determine the possible value gained from the architecture</li> <li>- Determine the associated benefit</li> <li>- Decide the score for each benefit</li> <li>- Repeat if necessary (for other benefits)</li> <li>- Determine total benefit score for the project (the average benefit score)</li> <li>- Model with ArchiMate</li> </ul>
<b>Analysis Techniques</b>	<ul style="list-style-type: none"> <li>- Cost &amp; Benefit Analysis</li> <li>- Financial Techniques</li> <li>- Scoring Methods</li> <li>- Cost Benefit Analysis Method (CBAM)</li> <li>- Quantitative risk–benefit assessment (RBA)</li> </ul>
<b>Output</b>	<ul style="list-style-type: none"> <li>- Estimation of Expected Project Benefit</li> </ul>

The concept of benefit is very similar to risk, except that it is a positive outcome instead of a negative one. However, unlike risk, there is no explicit representation of benefit concept in ArchiMate.

By definition, benefit is an advantage or profit gained from something. From architectural point of view, there must be something in the architecture that triggers a value gain, which result in a positive outcome, or in other words, a benefit. For this research, we proposed to model benefit using existing concepts available in ArchiMate, as depicted in Figure 27 below.

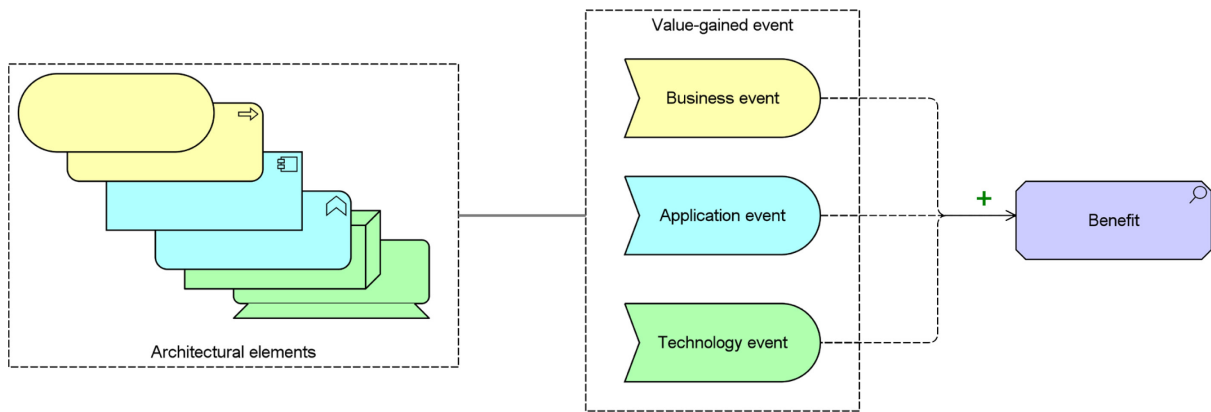


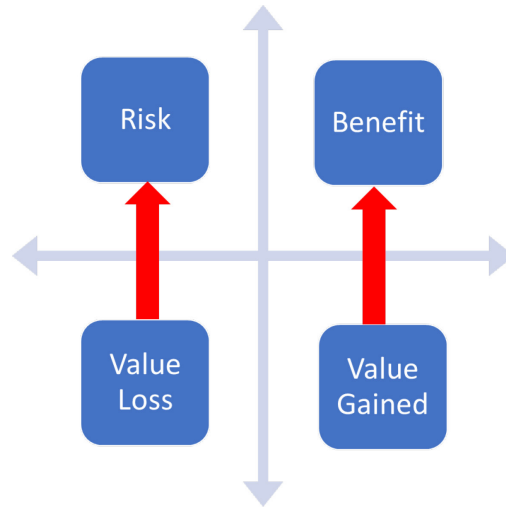
Figure 27 Benefit Concept Mapping in ArchiMate

The concept of benefit is very similar to the concepts in Risk and Security Overlay in ArchiMate. Since risk is a specialization of the assessment concept in ArchiMate, benefits can be modelled with architectural pattern as an ‘Assessment’ element. Comparably, the trigger that serves as a stimulus for the benefit can be modelled as ‘Event’. These are the events that might cause a value gain for the organization. The relationship between these two elements will be an influencing relationship with a positive influence since the event causes the occurrence of the expected benefit in a positive way. The type of Event element that can be used depends on situation in the architecture and which architectural layers it belongs to. From conceptual point of view, these two concepts are very similar to each other. The essential difference between the two construction is the influencing relationship, in which one is positive and the other is negative influence. This is illustrated in Table 19 below.

Table 19 Comparison between Risk and Benefit Concepts

Cause	Relationships	Effect
Loss event	(Association)  (Negative Influence)	Risk
Business event Application event Technology event	(Association)  (Positive Influence)	Benefit

The comparison between the concept of risk and benefit could also be presented in a matrix, as shown in Figure 28 below. In this figure, the vertical axis represents the positive (right side of the axis) and negative (left side of the axis) influence of the relationships. On the other hand, the vertical axis represents the cause (downside) and the effect (upside) of the relationships.



*Figure 28 Risk vs Benefit Matrix*

Since the concept of modelling benefit with ArchiMate is already explained, the next step is to model the benefit of the project using ArchiMate. An example of modelling benefit analysis is presented in Figure 29 below.

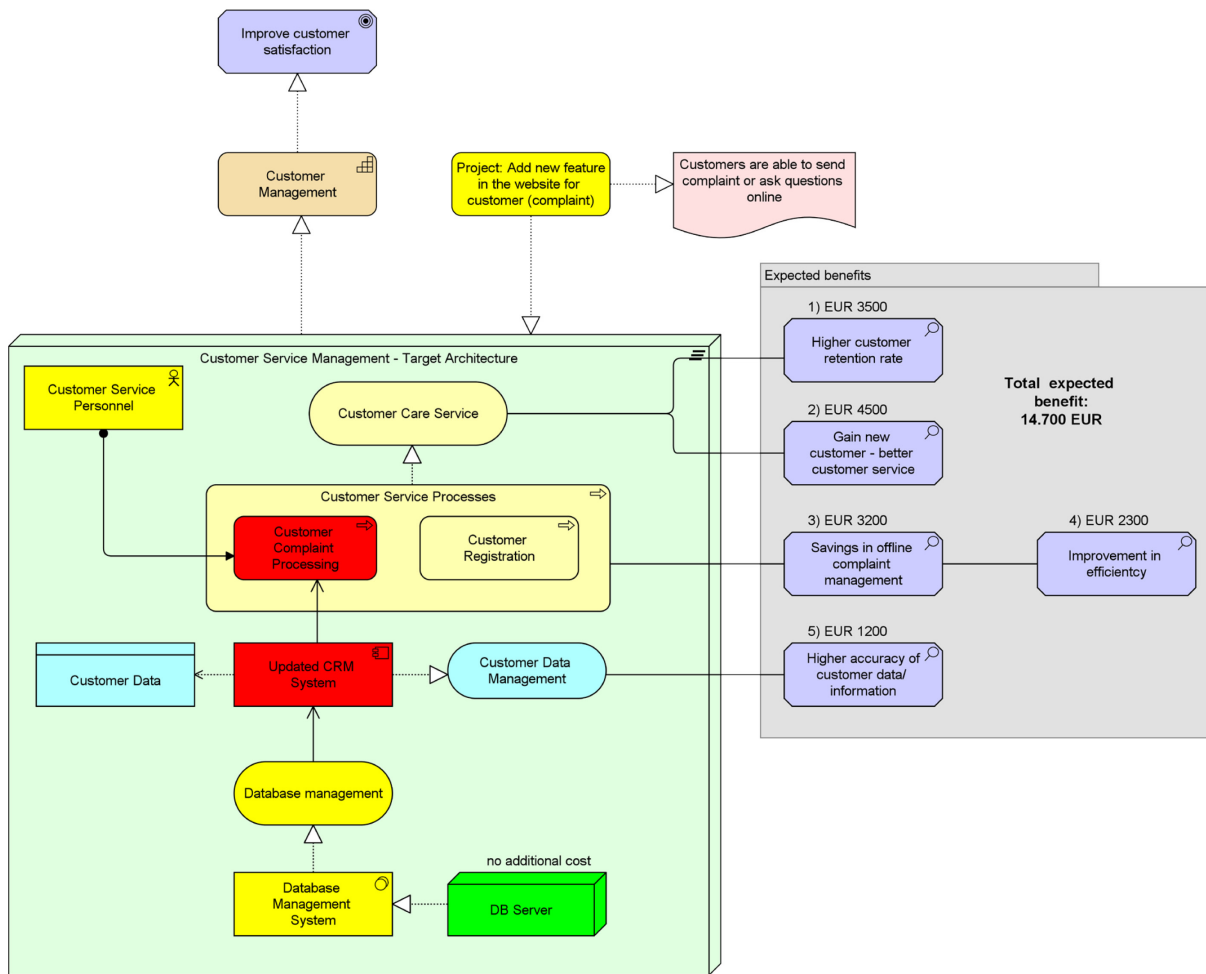


Figure 29 Modelling Benefit Analysis with ArchiMate

### 3.4 Project Selection Analysis with DEA method

#### 3.4.1 Step 8: Project Selection Analysis

The last step in the proposed method is to select the best projects based on the criteria and analysis performed in previous steps i.e. capability improvement, project cost, project risk, and project benefit. The main goal is to minimize the cost, time required, and risk, while maximizing the project benefit and capability improvement. The activities required to achieve this goal is described in Table 20 below.

Table 20 Summary of Step 8

Step 8 - Project Selection Analysis	
<b>Objective</b>	To achieve optimum project selection in order to address an organization's concern or problems
<b>Inputs</b>	<ul style="list-style-type: none"> <li>- Project Impact/ Suitability Analysis</li> <li>- Cost Analysis</li> <li>- Risk Analysis</li> <li>- Benefit Analysis</li> <li>- Project data</li> </ul>

<b>Activities</b>	<ul style="list-style-type: none"> <li>- Prepare the information from previous steps including impact on capability, project cost, risk, benefit</li> <li>- Prepare project data: expected implementation time</li> <li>- Define input and output for analysis (DEA)</li> <li>- Normalized value if necessary (DEA)</li> <li>- Run the DEA calculation using software (DEA)</li> <li>- Calculate the efficiency score for each project (DEA)</li> <li>- Interpret the result</li> <li>- Select project</li> </ul>
<b>Analysis Techniques</b>	<ul style="list-style-type: none"> <li>- AHP</li> <li>- DEA</li> <li>- TOPSIS technique</li> <li>- Other MCDA methods</li> </ul>
<b>Output</b>	<ul style="list-style-type: none"> <li>- Project efficiency ranking based on defined input and output</li> </ul>

Data Envelopment Analysis (DEA) is a data oriented mathematical model for measuring the performances of decision making units (DMUs), that are evaluated by multiple and common inputs and outputs (Charnes et al., 1978). DEA is a widely recognized technique for evaluating the efficiencies of decision making units (DMUs). Because of its easy and successful application and case studies, DEA has been used to solve multiple criteria decision-making problems in various fields and areas. This includes selection of best vendors, evaluation of data warehouse operations, assessment of bank performance, etc. In this research, DEA method is used to find or select the most efficient project as a result of the analysis done in previous steps.

DEA method is chosen to be the approach for the project selection analysis because of several reasons. First of all, DEA can take different measurement units as input or output, instead of just one type of measurement. This is a big advantage especially in project selection process, where there are a lot of different things to be considered such as cost, risk, implementation time, and etc. Furthermore, some studies in the literature have shown the application of DEA method in project portfolio management, as explained in Chapter 2. The main objective of the DEA method for project selection process is also modelled using ArchiMate, as shown in Figure 30 below.

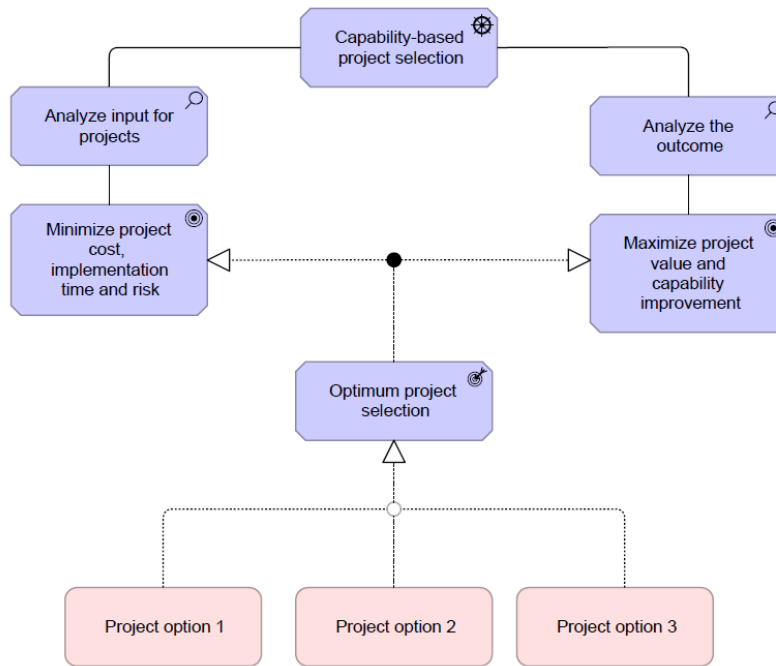


Figure 30 Project Selection Analysis, modelled with ArchiMate.

For this research, it is important to note that an existing DEA-solver software is used for the application of the DEA method. Thus, the model and objective function is based on the selected software. The software that will be used in this research is DEAFrontier software by Joe Zhu. The software is developed based upon Professor Zhu's years of DEA research and teaching experience and is written in an effort to minimize the possibility of misinterpretation of DEA models during coding. It uses Excel Solver as the engine for solving the DEA models. The main reason of choosing this software is because the free trial version of this software allows the usage of all DEA basic models, which is important for this research.

In order to run the DEAFrontier software, Excel Solver must be installed in the Excel. The application of this software is very straightforward and thus could be easily used even by non-technical users since it provides a very comprehensive guideline on how to use the software with Excel along with explanation about different DEA models available in the software.

Since the focus on this research is not on the mathematical aspects of DEA, in-depth exposure on the equations will be excluded. Interested reader may refer to the research or books mentioned in the reference for more detail regarding the DEA models, such as the book by Zhu (2014) and Cooper et al. (2006).

The first step that must be done is selecting the input and output for the selection. In the previous section, it is already explained that cost is amongst the most important criteria mentioned in the literature. Other than that, benefit or profitability, risk, and completion time are also notably cited in the previous studies (Asosheh et al., 2010). In addition to the that, improvement on the relevant and strategic capabilities based on a specific concern is also added for one of the criteria for project selection. The final selection of inputs and outputs chosen for this research along with the sources for each is summarized in Table 21 and 22 below, respectively.

Table 21 Input selection

Input	Name	Source
Input 1	Project cost	Result of Step 5
Input 2	Project risk	Result of Step 6
Input 3	Implementation time	Project data

Table 22 Output selection

Output	Name	Source
Output 1	Project benefit	Result of Step 7
Output 2	Impact on capability	Result of Step 3

The next step is to populate the input and output data based on the source mentioned in Table 5 and Table 6. Data population could be done using Microsoft Excel with the guideline provided by DEA Frontier Software. Example of how to populate the data is illustrated in the Table 23 below.

Table 23 DEA Data Population

Projects	Cost of projects (million euro)	Implementation time (weeks)	Risk scale (1-4)	Benefit (thousand euro)	Customer Satisfaction (weighted score from AHP)
Project 1	15	40	2	5	35,7123
Project 2	10	35	2	5	36,4202
Project 3	8	55	2	3,8	26,7500
Project 4	17	40	1	2	17,8838
Project 5	8,5	60	1	7	31,3421
Project 6	5	55	1	3,8	15,4525

In the above example, ‘customer satisfaction’ is the strategic capability that needs to be improved based on the capability analysis executed in the previous step. The score for this criterion is based on the impact of each project on the improvement of this capability, in order to solve the problem faced by the organization.

Then, the DEA calculation using the software is done using previously populated data. The result of the calculation will be shown by the DEA Frontier software. Based on data on Table 23, the result of the DEA calculation is shown in Table 24 below.

Table 24 Result of DEA calculation using DEA Frontier

DMU No.	DMU Name	Efficiency
1	Project 1	0,94066
2	Project 2	1,00000
3	Project 3	0,90740



<b>4</b>	Project 4	0,71074
<b>5</b>	Project 5	1,00000
<b>6</b>	Project 6	0,92286

Based on the result above, project 2 and project 5 are the most efficient projects considering the given input and output. The reason is because the efficiency score of these both projects are equal to one. Moreover, slack analysis is also automatically created by the software which enable the user to analyze the result in more depth. Slack analysis can provide guidelines to derive the optimal level of input and output resources for each decision-making unit, or in this case, for each project. By conducting slack analysis, we can determine which measured inputs are inefficient and do not add to quality, as well as which inputs should be increased (and by how much) to enhance the efficiency. Example of the slack analysis provided by the software is presented in the table below.

Table 25 DEA Slack Analysis

DM U No.	DMU Name	Input Slacks			Output Slacks	
		Cost of projects (million euro)	Implementatio n time (weeks)	Risk scale (1-5) (low to high)	Benefit (thousand euro)	Customer Satisfaction (weighted avg from AHP)
<b>1</b>	Project 1	4,31597	0,00000	0,00000	0,20130	0,00000
<b>2</b>	Project 2	0,00000	0,00000	0,00000	0,00000	0,00000
<b>3</b>	Project 3	0,00000	0,00000	0,92990	2,05687	0,00000
<b>4</b>	Project 4	7,21189	0,00000	0,00000	1,47007	0,00000
<b>5</b>	Project 5	0,00000	0,00000	0,00000	0,00000	0,00000
<b>6</b>	Project 6	0,00000	18,18571	0,38000	0,00000	1,56178

In summary, the results of the analysis from the previous steps are used as criteria in order to assess the projects. Detailed activities on how to achieve the result is described in detail in this chapter, starting from capability analysis using the AHP method, EA-based analysis, and lastly project selection analysis using the DEA method. To conclude, the proposed method incorporates the result of capability analysis with the result of project assessment (i.e. project impact, cost, risk, and benefit) in order to determine which project to be selected based on a specified concern or problem at any given time. Thus, the proposed method could help organizations to analyze their planned investments or project proposals to make sure that the selected investment or project will really solve the problem they have in the first place.

## 4 Demonstration

The objective of this chapter is to demonstrate the application of the proposed method in a real case. This is considered important as part of the research methodology explained in Chapter 1. Applying the method to a case is necessary to show that the method will be applicable in a real situation which exists in organizations.

For this purpose, a case study of a large European power supplier company is chosen. The information about the case is gathered from scientific papers by Franke et al. (2010) and Iacob, Quartel, et al. (2012).

However, due to the data limitation, some assumptions and additional information are added by the author while implementing the case study. In a real case, all the required information should be determined from related stakeholders or documents in the organization.

Firstly, a brief description about the case along with the assumptions needed to apply the method is provided in Section 4.1. Next, detail explanation on how to apply the proposed method to the case study is presented in Section 4.2.

### 4.1 Case Description

The case of European Power Supplier (will be referred as EPS) company mentioned in the references are not sufficient to depict the current situation in the company. Thus, some assumptions need to be made regarding the case. First, it is assumed that EPS is a power company that supplies mainly electricity to their customers. Also, EPS is active in all parts of the value chain which includes generation, distribution and sales. The end users of EPS include everything from industries and private households to commercial buildings that are connected to and consume electricity from the regional grids owned by EPS.

The main vision of EPS is to be the customers' trusted energy partner, while also optimize current operations, improve sustainability, and work on new energy technologies that are more sustainable from environmental and economic point of view (renewable energy). The main strategic objectives of EPS include create energy products that will benefit customers, improve operational efficiency and effectiveness, finding and implementing energy-efficient technologies, and providing a safe working environment for their employees.

In order to apply the proposed method for the EPS case, a capability map of EPS must be defined first since the business capabilities of the companies were not described in the source of the case study. Some existing capability maps that are defined for other organizations were used as references to build capability map for EPS. It is helpful in determining the general business capabilities that most organizations should be able to do. However, these capabilities do not portray the core business capabilities of an energy/ power supplier company. Therefore, additional references on utility industry specific business capabilities must be included to build EPS capability map. For this reason, APQC Process Classification Framework specifically for Utility and Energy Industry was used as our main reference to acquire the core business process in a typical energy or power company (APQC, 2016). These capabilities derived from this framework are described in more detail in Appendix 5.

However, it is also mentioned in the above framework that some capabilities are inappropriately constructed to reflect the delivery of 'products and services' in the utility industry. These categories are more suitable for a goods manufacturing industry. Specifically, the category is all about 'supply chain' on the assumption that an organization buys stuff, manufactures or value adds to create a physical product, warehouses it, and physically delivers it to customers. However, this is not the case for utility and energy companies. Utilities do buy and warehouse stuff but they use all this stuff to build and maintain their productive and non-productive assets, rather than sell and deliver it to customers.

In the Energy and Utility (E&U) industry, like EPS, the delivery of 'product' is actually a process of operating the utility plant and networks (power grids, gas and water pipe networks) and measuring flow of these products (electricity, water and gas). In the framework, the new Category 14.0 captures these E&U-specific operations and metering processes. Thus, for the capability development, this category was analyzed in more depth in order to understand the core capabilities in energy and utility industry. Below is the summary of the lower level of Category 14, based on the framework.

*Table 26 Operate Utility Assets - Level 2 (APQC, 2016)*

<b>Category</b>	<b>Name</b>	<b>Description</b>
<b>14.1</b>	<b>Operate utility network and pipeline assets</b>	Ensuring the delivery of electricity, gas, and water to the customers.
<b>14.2</b>	<b>Operate major utility plant</b>	Operating power plants for generating electricity, water purification facilities, and treatment plants to achieve water quality standards.
<b>14.3</b>	<b>Collect and manage utility metering data</b>	Collecting, processing, aggregating, and distributing meter data from water meters and energy meters. Manage meter information for billing and revenue collection. Control the use and production of electric energy, gas usage, or water consumption through meter data analysis.
<b>14.4</b>	<b>Manage and operate utility metering assets</b>	Managing manual or automated metering assets and record usage/ other useful information. Utilities manage and conduct all aspects of metering operations for both traditional metering and advanced metering types.

As can be seen from the description in the table above, the first is more related to the delivery of power to the end-customers. Even though the name of the sub-category does not represent this, but the utility network and pipeline assets must be maintained to ensure efficient power delivery to customers. Meanwhile, the second sub-category is more related to the generation of power, whether it is electricity, gas, water, etc. The third and fourth sub-categories basically focus on the measurement of the power consumption of usage. The difference is sub-category 14.1 is more about the collection of usage data via different devices while sub-category 14.4 is more related to managing the data and record of the measurement as part of sub-category 14.3. Thus, in order to develop industry-specific capabilities, these

sub-categories explained in Table 26 will be considered as the high-level business capabilities, that are specifically for energy and utility industry such as EPS organization.

Next, interviews with the business stakeholders could be conducted to determine the decomposition of the high-level capabilities. In Figure 31 below the complete representation of EPS’s capability map is provided based on the analysis above.

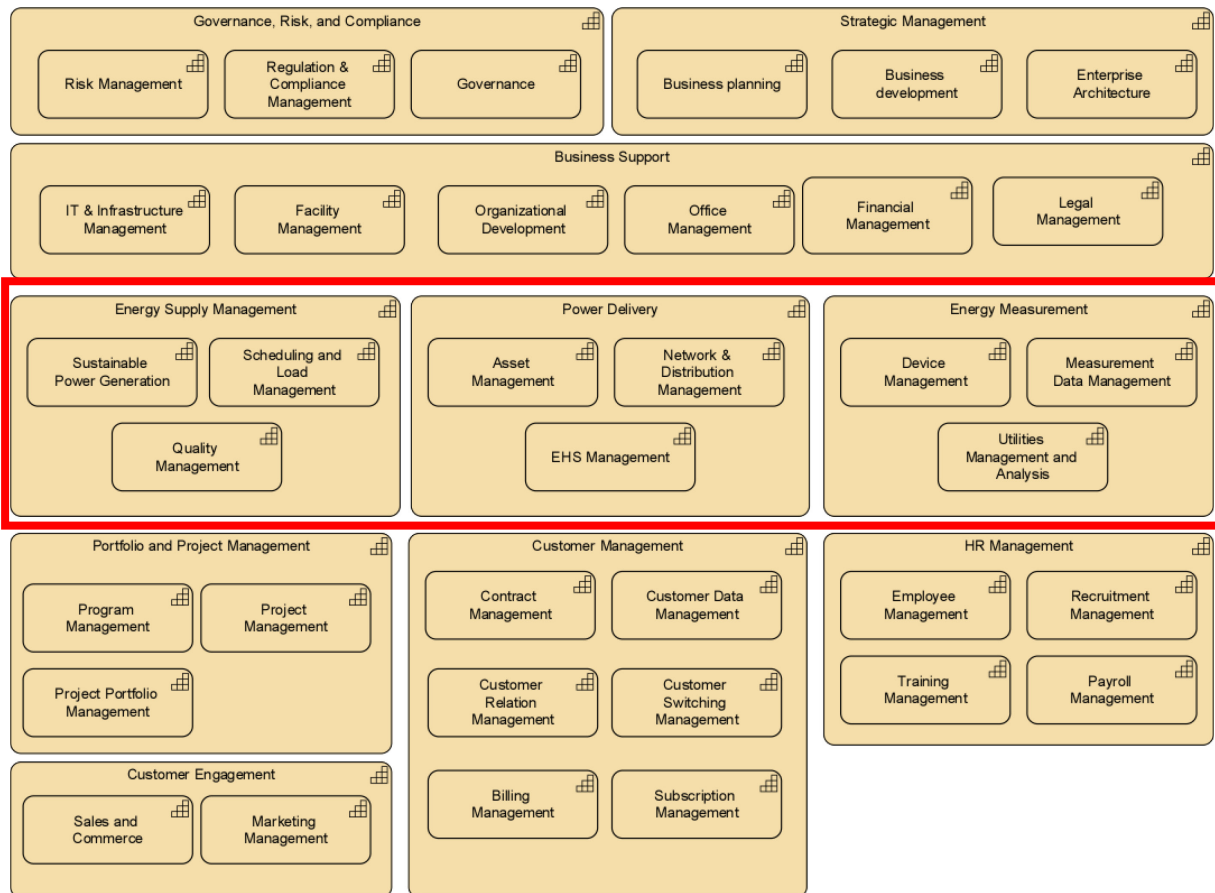


Figure 31 EPS Capability Map

The capability map for EPS consists of seven generic capabilities three industry-specific capabilities as level 1 capability. The industry-specific capabilities are marked with red box to differentiate it from the generic capabilities. This include Energy Supply Management, Energy Delivery, and Energy Measurement capabilities. The sub-capabilities are derived from the activities mentioned in the APQC Framework.

## 4.2 Applying the Method to the Case of EPS

A recent study that was done in 2016 reported that electric utility providers continue to struggle to match other industries in customer satisfaction. It is also reported in the study that utility industry need to learn from other high-performing service providers to put their customers first. In addition, it was also mentioned that customer expectations will continue to increase, and utility and energy companies need to have a mindset of continuous improvement to be able to keep up.

Since customers are the essence of the business in EPS, and customer satisfaction is considered as EPS's top priority, it is important to address the issue of low customer satisfaction rating in EPS.

It is also important to note that besides customers, the energy and utility market will go through a major transformation in the upcoming decade. Assets are aging, workforce is aging, customers are switching supplier and these issues are causing pressure on investment decisions. Thus, the proposed method will be applied to EPS case with the objective to determine which projects or what investments should be performed first in order to address the issue of low customer satisfaction rating in EPS.

In the next section, the steps to apply the method will be explained in more detail based on the described problem.

### 4.2.1 Step 1: Strategic Capability Analysis

The objective of this step is to determine which capabilities that the EPS must focus on in order to address the concern related to low customer satisfaction. Since the concern was already explained in previous section, the next step is to determine the assessments that might cause the problem. This could be agreed based on reconciliation of assessments by several parties or business units that are related to the concern. For this, assumptions on the relevant assessments were made based on research on customer satisfaction in utility industry (reference). The summary of assessments found for low customer satisfaction rating in all business units is depicted in Table 27 below.

*Table 27 Assessment Related to Problem*

<b>Issue/ Concern</b>	<b>Assessment(s)</b>
<b>Low customer satisfaction rating</b>	Unresolved complaints from customer
	Inefficient customer switching process
	Poor customer service
	Ineffective complaint processing
	Not transparent billing process
	Lack of channel in customer service

Then, with the basis of the above assessments, relevant capabilities must be chosen. This could be done using assessment and capability relationship table. Since in previous section the capability map was defined until level 2, it is only fitting to choose the suitable level 2

capabilities for this step. The first capability that is relevant is ‘Customer Relation Management’ capability. In addition, ‘Billing Management’ capability is also related to the problem since one of the assessment stated that the billing process to customer is not transparent and cause low customer satisfaction rating. Next, ‘Customer Data Management’ was also chosen since it is related with switching process and complaint processing. Lastly, ‘Measurement Data Management’ capability is also considered relevant since customer switching process also includes the power usage measurement process, which is managed in this particular capability. The relationship between the main concern, related assessments, and relevant capabilities are summarized in Figure 32 below.

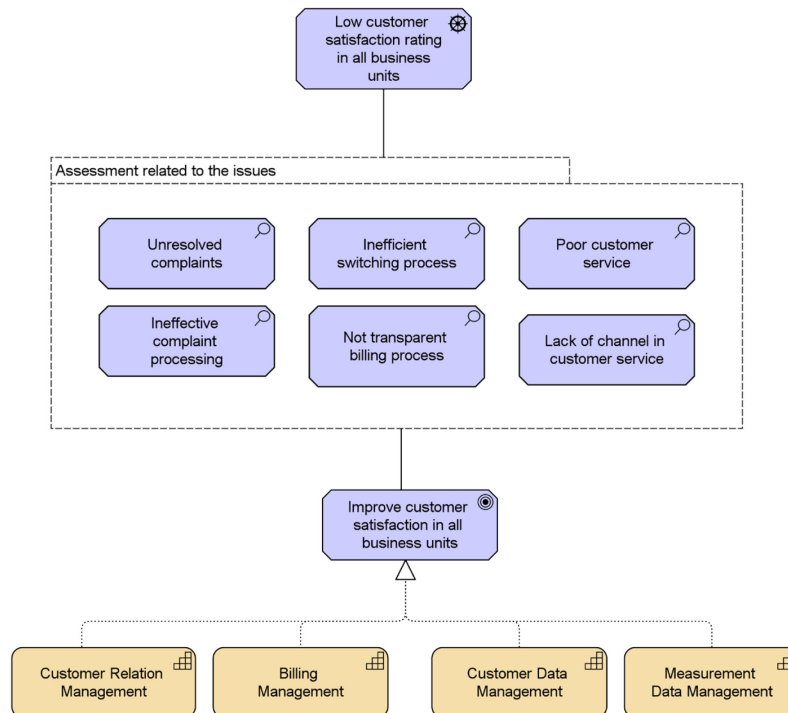


Figure 32 EPS Capability Analysis

Analytical calculation using AHP can be conducted after having the assessments and capabilities based on the specific concern of EPS. As explained in the previous chapter, the analytical hierarchy process (AHP) will be used in this step to determine the most important capabilities to solve the problem of low customer satisfaction rating in EPS based on the defined assessments. The result of the AHP calculation is illustrated using ArchiMate in Figure 33. The score for each capability depicted in the figure is obtained from the AHP method. Detail calculation of the AHP method for this part can be found in Appendix 6.

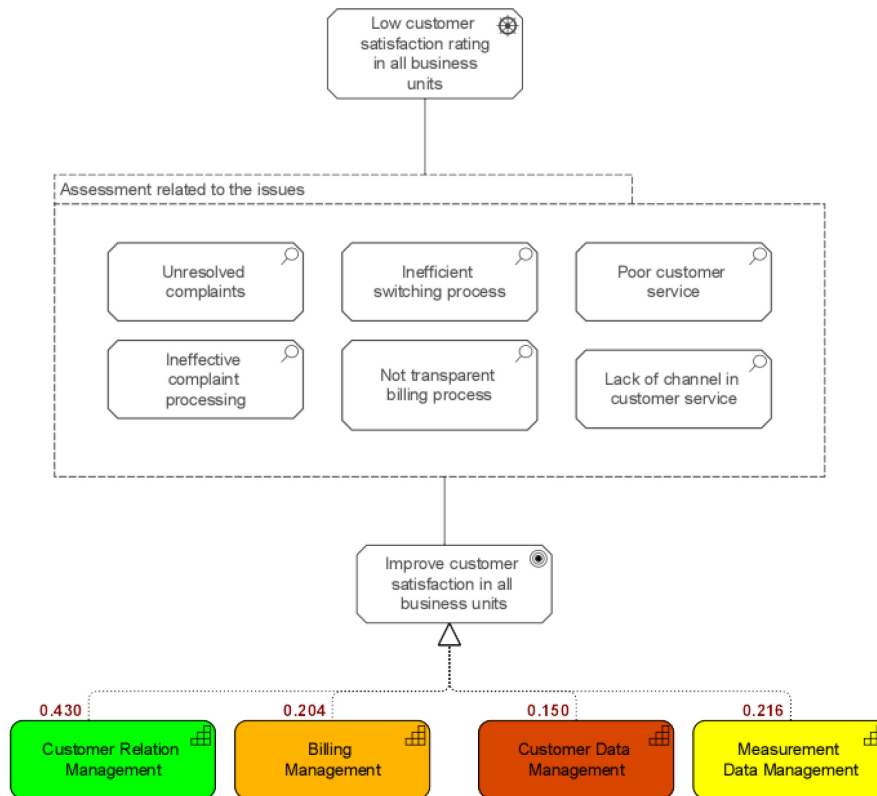


Figure 33 Result of AHP Calculation, modelled with Archimate

Based on the result above, ‘Customer Relation Management’ capability has the highest score and thus could be concluded that this capability has the biggest impact to address the concern the company has, which is low customer satisfaction rating. This also implies that if EPS needs to focus on improving its ‘Customer Relation Management’ capability in order to solve the problem of low customer satisfaction. Based on the explanation provided in Chapter 3, capabilities that have a score from AHP higher than  $1/n$  ( $n$ = the number of selected capabilities) should be considered as the relevant capability for the concern. In this case, since there are four relevant capabilities, any capabilities that have a score higher than 0.25 must be selected as criteria for the final selection. Thus, the next step will be conducted based on this result, focusing on ‘Customer Relation Management’ capability.

#### 4.2.2 Step 2: Capability Metrics Analysis

As mentioned before, ‘Customer Relation Management’ capability is chosen as input based on the result of Step 1. In this step, capability metrics for ‘Customer Relation Management’ capability must be defined in order to be able to conduct AHP calculation to determine weights for each capability metric. Considering the high-level problem to be solved, capability metrics that are chosen to be included are task time, response time, data accuracy, and data transparency, as depicted in Figure 34. The next activity is to calculate the weight for each metric as part of the AHP method. The result of the weight calculation using AHP method is also illustrated in Figure 34 below.

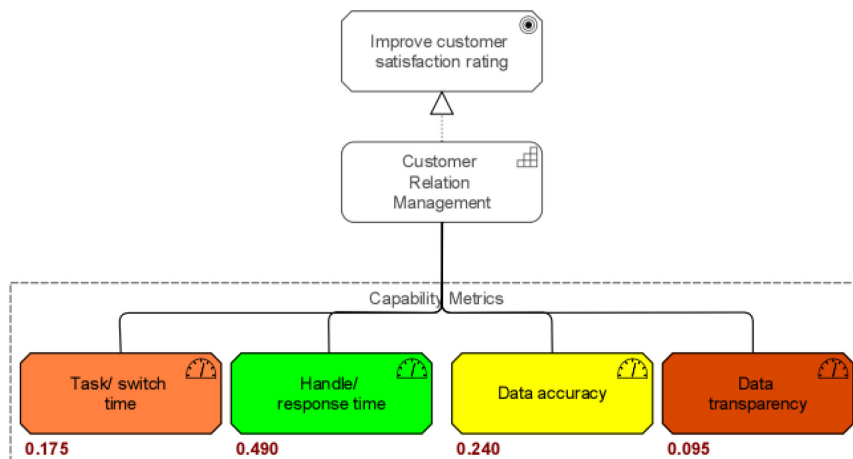


Figure 34 EPS Capability Metrics Analysis

As can be seen from the figure above, the weights of the metrics vary quite a lot. It is important to determine these weights in order to analyze the impact of possible projects on the capability improvement, since these metrics act as a quantifiable measure that is used to track and assess the capability. Thus, the weights of the metrics obtained from the AHP calculation will be used as inputs for the next step, which will be calculated also with the AHP method.

#### 4.2.3 Step 3: Project Impact Analysis

For this step, the first activity that must be done is to determine the possible projects that need to be included in the selection process. Since this information regarding possible projects is not included in the case study, some assumptions related to proposed projects were made. First, information in the case related to application consolidation was used and it was considered as one of the project to be analyzed, along with other assumptions-based projects that are not part of the case study.

In order to choose the possible projects, information related to the functions and systems mentioned in the case was also considered. This is to ensure that the chosen projects are still relevant with the case and the concern of EPS mentioned in the previous section. Thus, in addition to the application consolidation project, two other projects are selected. This include smart meter integration with billing, and online self-service feature for EPS's customers.



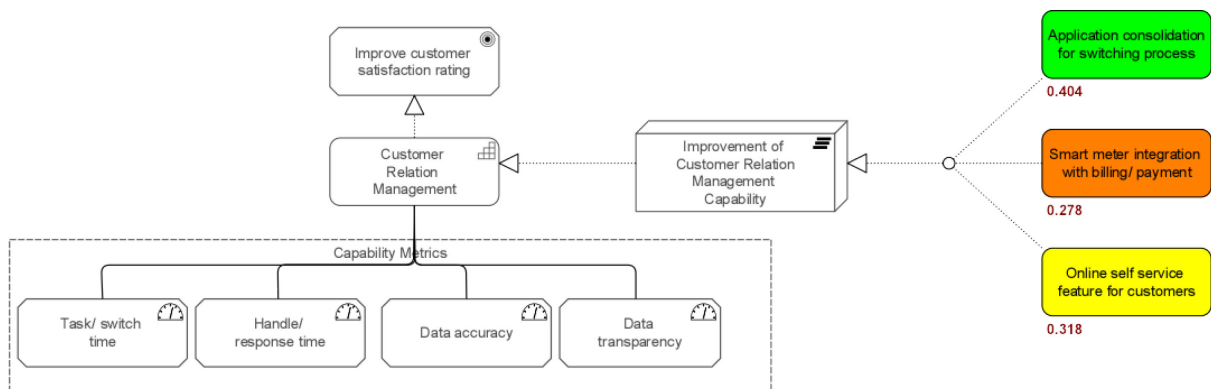


Figure 35 EPS Project Impact Analysis

Once the projects have been selected, the next step is to conduct pairwise comparisons among these projects, using the metrics specified before as the criteria. This is basically part of the AHP method, as explained in previous chapter. The purpose of the pairwise comparison is to compare the projects with each other with regards to each of the capability metrics defined. For example, the decision-makers will compare the impact of the projects to the improvement of response time to customers. Then, it is also the same step for the rest of the capability metrics. As a result, the weights of the capability metrics from Step 2 is combined with the result of pairwise comparisons to obtain the final score for each project. The step-by-step calculation of the weights and scores using the AHP method is presented in Appendix 7, while the result is also presented in Figure 35.

As can be seen in the figure, the score of each project as the result of AHP method represents the impact of the project to the improvement of 'Customer Relation Management' capability with regards to the defined capability metrics. It implies that online self-service feature for customers project is considered the best option in order to improve 'Customer Relation Management' capability. These scores on the impact of all the possible projects on capability improvement will be used as input for project selection process.

#### 4.2.4 Step 4: Impact Analysis

As mentioned in previous section, this analysis must be done for each of the proposed projects to be analyzed. For the purpose of demonstration, project 1 (application consolidation for switching process) will be chosen for all of the EA-based analysis and modelling. Moreover, this particular project is chosen since some information related to this are available in the references (Franke et al., 2010; Iacob, Quartel, et al., 2012). Once the data regarding the proposed project has been gathered, the next step is to determine the current (as-is) and future (to-be) architecture to be realized by the project. The processes, functions, and systems described in the following are all accurate depictions of the actual situation at the company. However, some elements in the architecture like databases and business services were added to showcase modelling across different architectural layers, which is

most likely the case in most organizations. Based on the information on the sources and the defined assumptions, as-is and to-be architecture were developed using Archimate and presented in Figure 36 and 37 below, respectively.

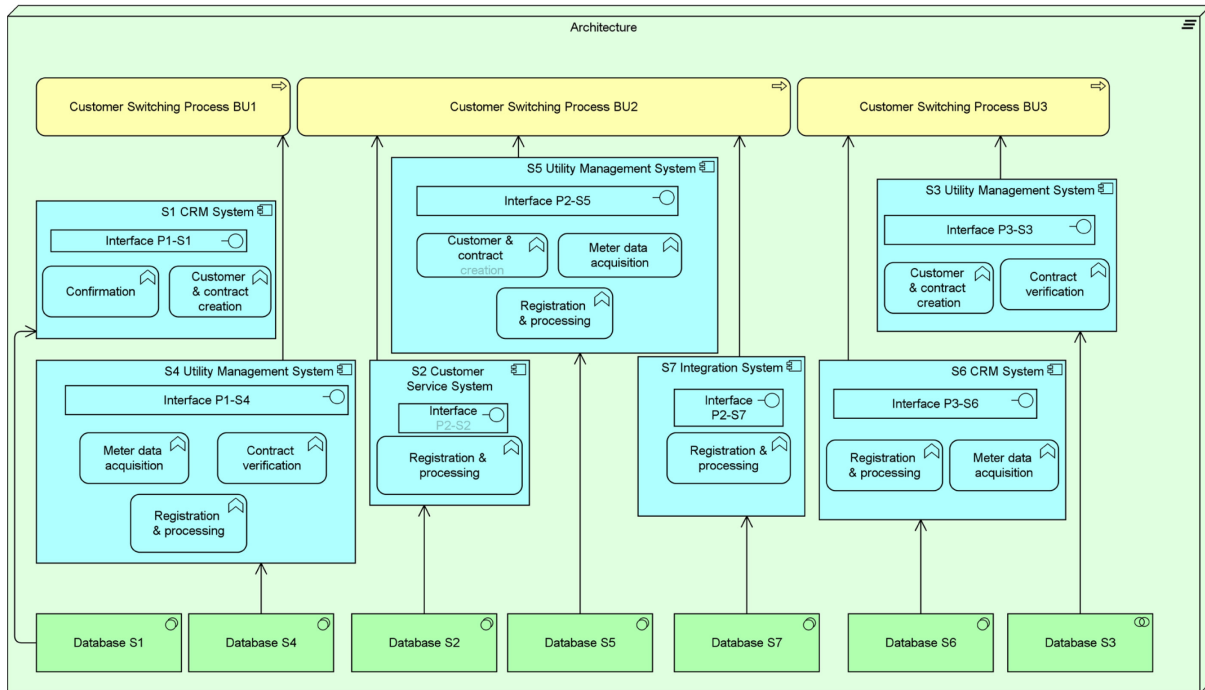


Figure 36 EPS As-Is Architecture

In the current architecture, there are in total seven different applications that are used for the customer switching process in all business units. It can be seen from the figure above that most of the functions are the same and exact duplicates of other functions, even though it is from different applications.

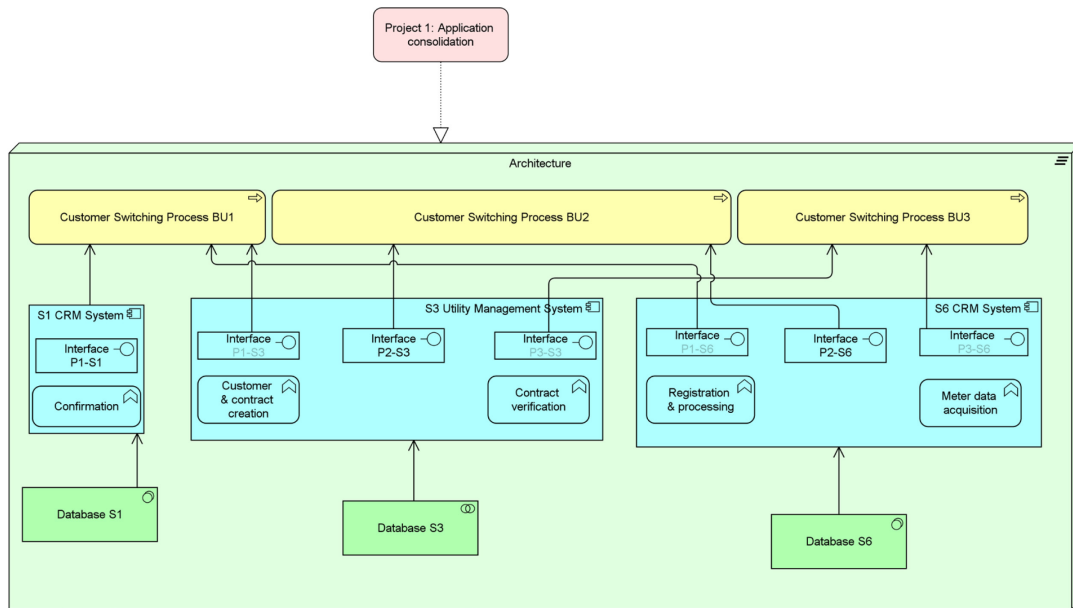


Figure 37 EPS Target Architecture

As can be seen in both figures above, the current architecture showcases several duplications of functions in the systems that realize the requirements in the business process. With the target architecture, the functions needed for the business process are still available with consolidation of systems that have duplicate functions. Next, we need to identify the types of changes as the impact of the project to the architecture based on specified types of changes mentioned in Chapter 3. The result of the change impact analysis for the EPS case is depicted in the figure below.

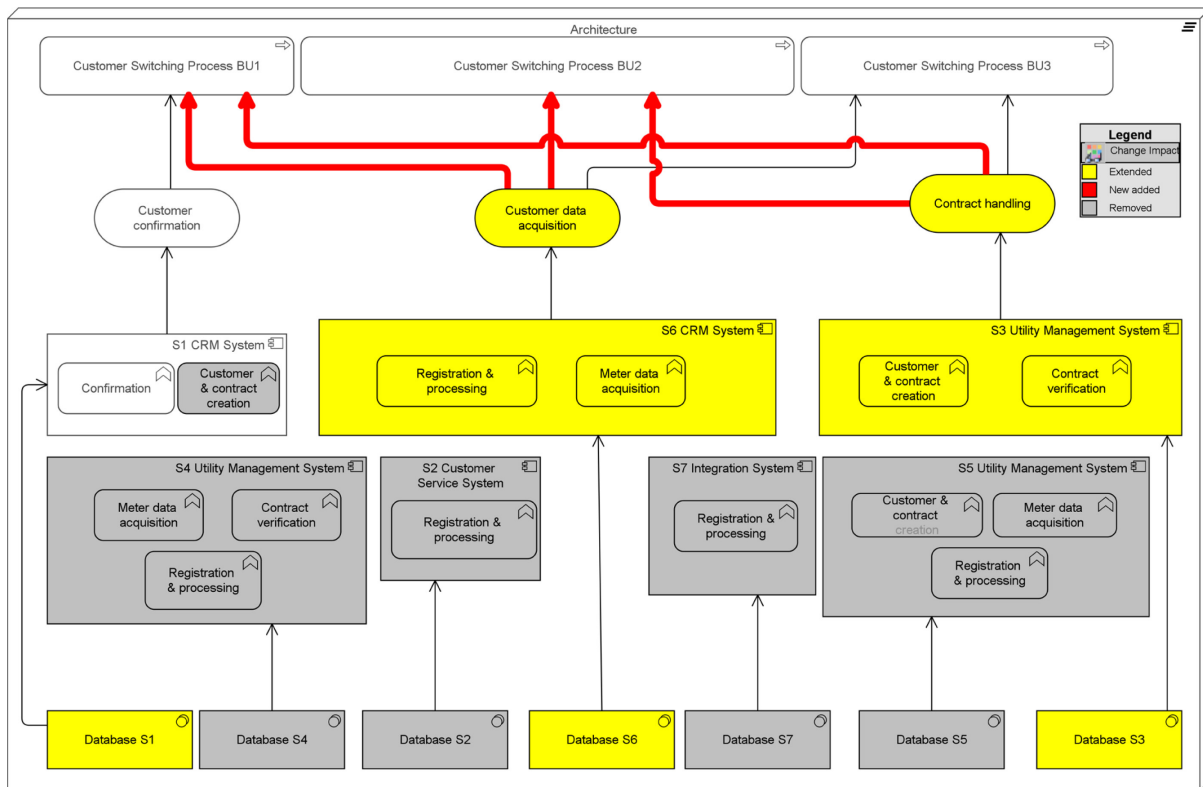


Figure 38 EPS Change Impact Analysis

As can be seen in the figure above, four existing systems will be removed along with four databases which are associated to the systems. In addition to that, the customer and contact creation function that is originally part of System 1 CRM System will also be deleted since this function will be served by System 3 Utility Management System. Also note that the relationships associated with the deleted elements will also be removed from the architecture.

Besides deletion, several modifications of elements need to be taken place. Firstly, the databases need to be extended since it will serve all of the three business units instead of just one business unit. Secondly, the application functions in System 3 and System 6 must also be modified since these functions will be also used by 2 additional business units. Thus, modifications must be done to ensure all of the requirements from the 2 business units will still be satisfied. Moreover, modifications are necessary to make sure that the functions provided by the system will be applicable for the customer switching processes for the new business units. With regards to System 1, no modification is needed since this system will only be used for customer switching process in one business unit, and no additional processes will use the system and the function based on the target architecture realized by the project. That means the consolidation project will have no impact on System 1 and confirmation function in the application. The same thing applies for the application services that are realized by the modified application functions. Since the functions need to be modified, the corresponding application services will need to have some modification as well.

Once the types of changes for all elements in the architecture have been determined, the next step to analyze cost related to these changes could be performed.

#### 4.2.5 Step 5: Cost Analysis

As previously explained in Chapter 3, the objective of this step is to determine the expected project cost based on the change impact analysis as a result from step 4. Here, each of changes in the elements of the architecture will be analyzed along with the costs that could be generated in association with the change. In the next part, each of the impacted elements in the architecture as a result of the previous step will be explained in detail.

Firstly, if the impact analysis shows there is no change required for an architectural element, this means no cost will be analyzed for this element. Thus, cost analysis will be performed for the elements that have either addition, modification, EUR, or deletion type of changes.

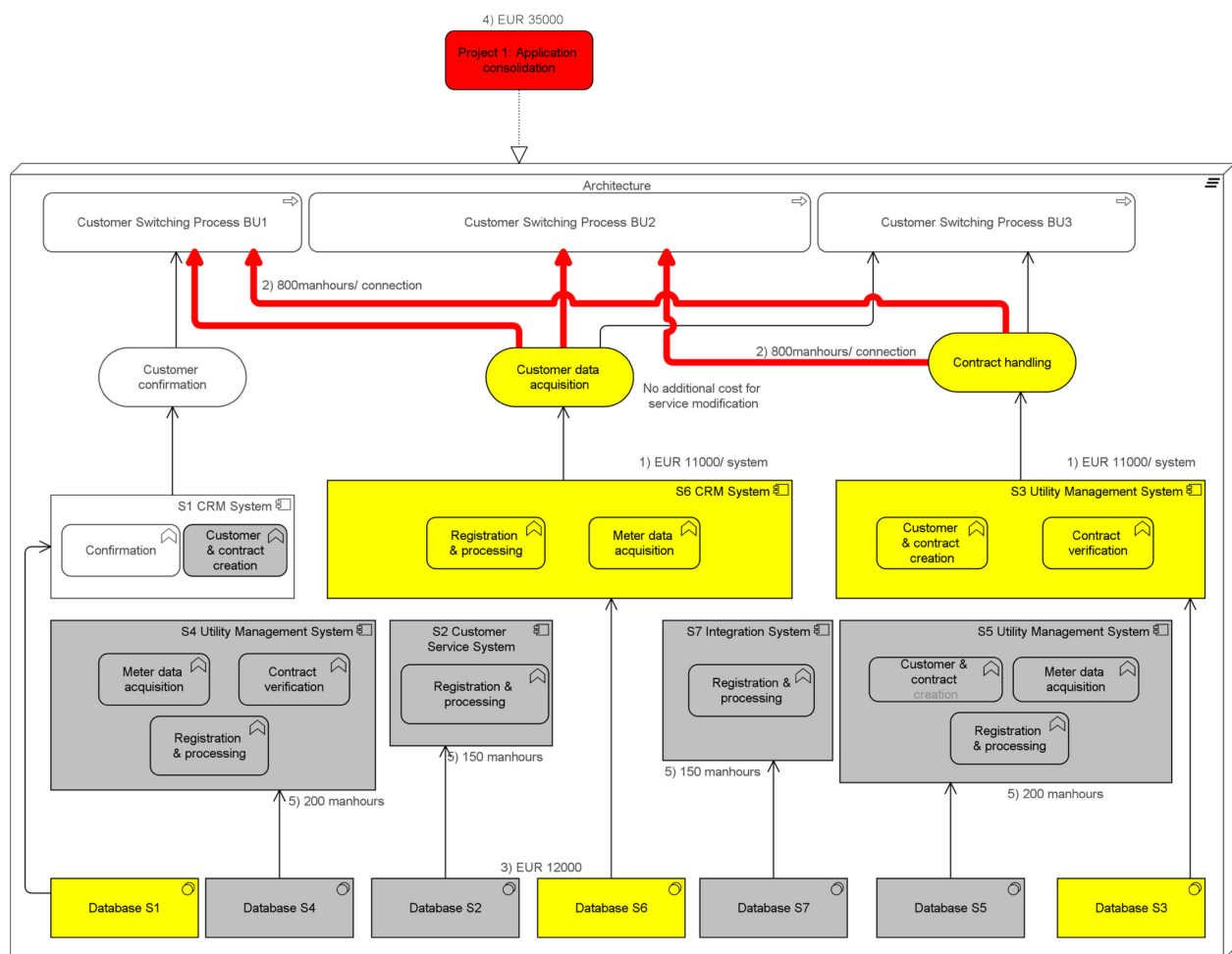


Figure 39 EPS Cost Analysis

As explained in the impact analysis part, some applications and the associated databases will be deleted from the architecture. Since most of the power supplier company in Europe is considered as a big company, it is assumed that these applications were used by many employees. Thus, it takes some efforts to remove it from all computers using it entirely. This is important to make sure that only used applications will be installed and maintained, which also means there will be no unused applications and databases exist since it will consume a lot of space to also maintain it. Thus, the first cost element derived from the impact analysis is the cost to remove the old applications and databases. Additionally, since the cost depends

on the size of the application, assumptions on how many man-hours needed for each application were made, as depicted in Figure 39 and Table 28.

While some databases will be removed, three existing databases will be extended to accommodate the need of all business units. This means before the databases are removed, the data need to be migrated first, and then integrated with the three databases. This is also called data migration process. It is important to take this into consideration when estimating cost because if it is not done properly, migration failure will lead to data loss, which is something that EPS wants to avoid. The cost of data migration usually depends on various things, such as what kind of data to be migrate, how to migrate it, and how long it will take for the preparation and for the actual data transfer.

In this particular EPS case, data migration occurs because some applications must be merged together to eliminate function duplications. The process of bringing these functions from one application to another application is called application integration process. This process is important to ensure that information in multiple systems or applications is always consistent. The difficulty level of and cost for application integration process depends a lot on what kind of applications that need to be merged. Usually, it is considered difficult when integrating legacy applications with new or Web service applications. For the EPS case, it is assumed that the merged applications are within the same type and thus the application integration cost is similar for each application, as depicted in the result in Table 28.

Besides the extension of data and application, we must also analyze the newly added elements that are not part of the existing architecture. As can be seen in Figure 4, this includes all the new connections that need to be made between the application service and business process. For example, the 'Contract handling' service will also be used by customer switching process in business unit 1 and 2, in addition to business unit 3. For these new connections, testing must be carried out to make sure that the application service does what it is supposed to do and satisfies the requirements of the customer switching process in business unit 1 and 2 before it is used by the end-users. The cost of testing also depends on the scope of the testing itself, whether it includes compatibility testing, acceptance testing, security testing, etc. For the purpose of this case study, it is assumed that the effort or the man-hours needed to test the new connection is similar for the other connections as well, since it is assumed that the size of the business units are similar.

Lastly, we also need to consider the cost of the project management. It is also important to note that the human or organizational costs are usually much higher than technical costs (Franke et al., 2010). Since the focus of the cost analysis in the method is on the cost generated from the change in the architecture, we only assume the cost of the project management in total, without detailing the breakdown of this cost.

Table 28 EPS Cost Analysis Result

No	Types of Cost	Description	Amount (in euro)
1	Application Integration Cost	2 system x 11.000	22.000
2	Testing cost	800 manhours x 4	3.200
3	Data migration cost	-	12.000
4	Project management cost		35.000
5	Uninstall applications cost	700 manhours x 10	7.000
	TOTAL		<b>EUR 100.800</b>

Based on the information explained in previous part, the result of the cost analysis is summarized in Table 28 above.

#### 4.2.6 Step 6: Risk Analysis

The next step that needs to be performed in the method is to determine possible risks derived from the project. As mentioned in chapter 3, in order to determine risk, we need to determine the events from architecture (using the impact analysis from Step 4) that could lead to possible value loss. In addition, the result of cost analysis might also be used to determine any risks associated with the impact analysis.

First of all, there is a risk that the project might not go as planned due to various reasons. This could be due to lack of resources, lack of time that leads to project delay, underperformed third parties, contractor failure, or there are unplanned changes in the requirements of the project. Besides risk of project incompleteness, there is also a risk of integration failure since application integration is the main activity of the project, as depicted in both impact and cost analysis. It is important to consider this risk since there is a high chance that it will fail to integrate with the existing systems. Also, if this risk cannot be mitigated, EPS will not be able to do the main customer switching process, whereas it is considered as a significant process, especially for customers. Lastly, since some databases need to be expanded, the risk of data corruption or data loss during migration will also occur as a project risk. When the data is migrated to the new system, some of the data may not migrate over from the source system due to various reasons such as compatibility and size of data. However, this risk can be evaded by conducting data migration testing. Summary of the risk analysis for the application consolidation project in EPS is presented in Figure 40 below.

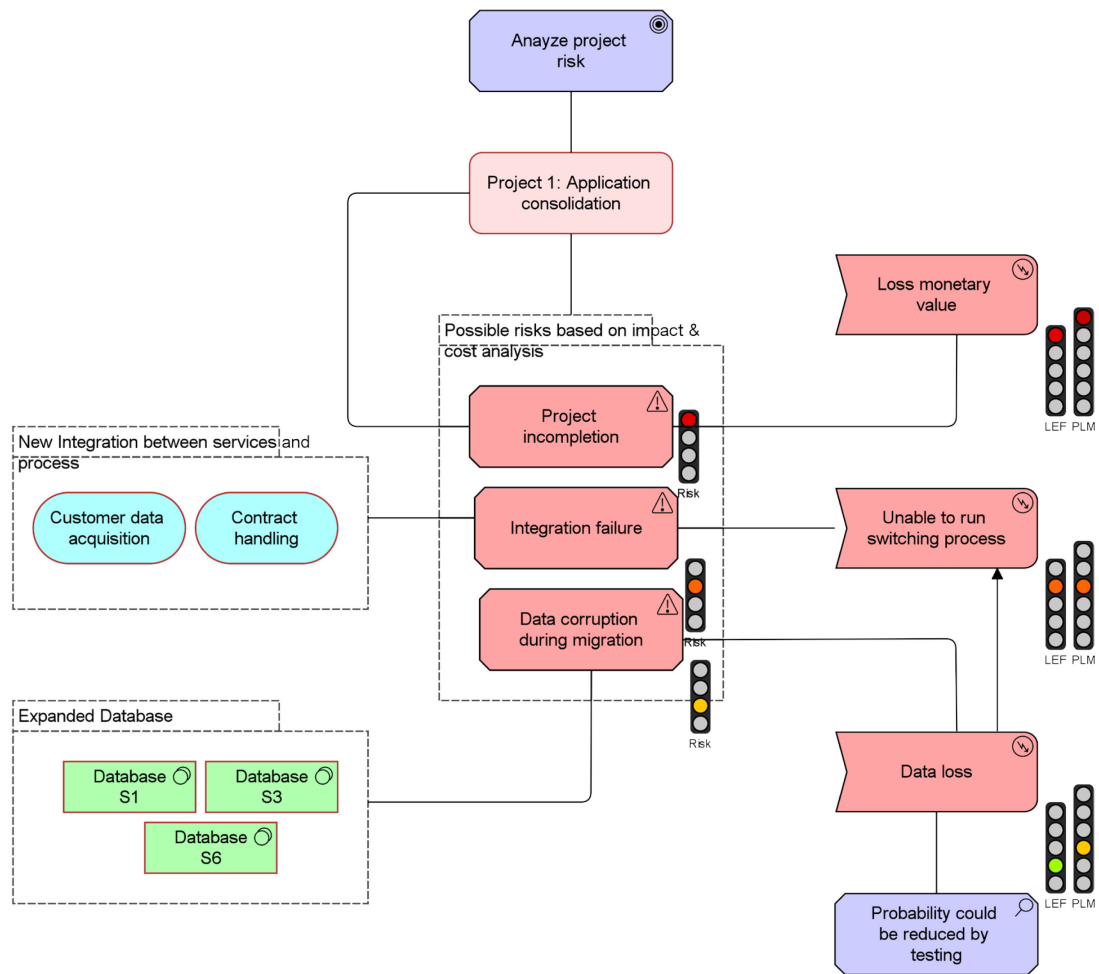


Figure 40 EPS Risk Analysis - Application Consolidation Project

Once the possible risks are identified, the next step is to determine the impact and probability of each risk in order to calculate the overall risk score for the project. As explained in Chapter 3, the risk factor for each risk is determined by multiplying the impact and probability level. Then, overall risk score of the project is calculated using the average of risk factors. The impact and probability for each risk, along with the risk factor calculation is provided in Table 29 below.

Table 29 Risk Score Calculation (EPS)

Risk	Impact	Probability	Risk Factor
1. Project incompleteness	6	5	4 (critical)
2. Integration failure	4	4	3 (high)
3. Data corruption/ loss	3	2	2 (medium)
<b>Average risk score</b>			<b>3 (high)</b>



When modelling the risk analysis in ArchiMate, the risk factor calculation can also be done automatically with the Enterprise Studio tool. Using this tool, the level of impact and probability can be determined using traffic light signs for LEF and PLM, as described in Chapter 3. When the impact and probability have been defined, the risk factor will be automatically shown, also represented using traffic light notations, as depicted in Figure 6. Furthermore, visualization of the risk analysis using risk heat map is also possible. It could also be done in the Enterprise Studio tool when the impact and probability of the risk have been determined. The risk heat map for EPS application consolidation project is presented in Figure 41 below.

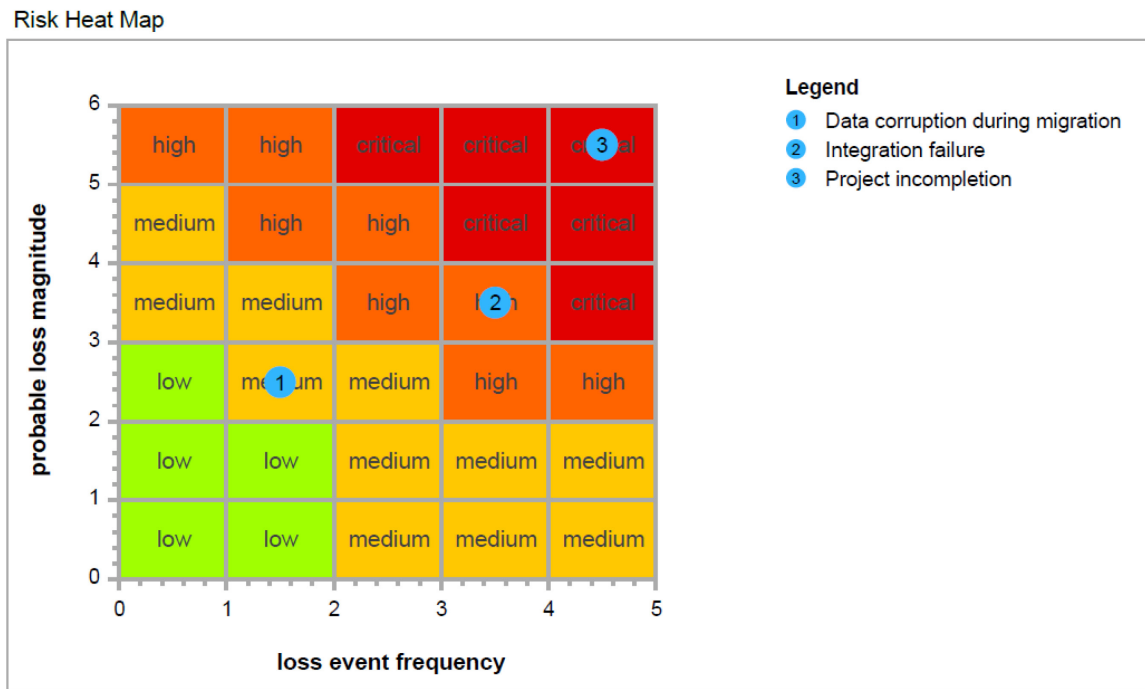


Figure 41 Risk Heat Map - EPS Application Consolidation Project

#### 4.2.7 Step 7: Benefit Analysis

After identifying the possible project risks, next step is to identify the potential benefit of the projects to be assessed. As explained in chapter 3, the benefit will be determined based on the change in the architecture as a result of impact analysis. Furthermore, in this case, the project to be assessed will be the application consolidation project in EPS.

The first step that must be done is to determine any parts from the architecture that might cause value generation for EPS. This is why the change impact analysis is used as an input for this step, so that the benefit could be analyzed based on the changes occurred in the architecture. After all benefits have been identified, next step is to decide on the importance level for each benefit in order to quantify the overall project benefit. For the EPS application consolidation project case, the identified benefits from the architecture will be explained first and then followed by a summary of the benefit score for the project.

First of all, the diversity of applications in EPS might create tremendous inefficiencies. Thus, the main purpose of the application consolidation project is to reduce these inefficiencies by

making sure no redundant applications were used. It is also shown in the impact analysis result that some applications will be removed due to its redundancy. This means the cost of supporting and maintaining these applications could be reduced by the implementation of the project. Furthermore, the impact analysis also depicted that there will be no new application added after the consolidation project. This implies to zero occurrence of application procurement cost.

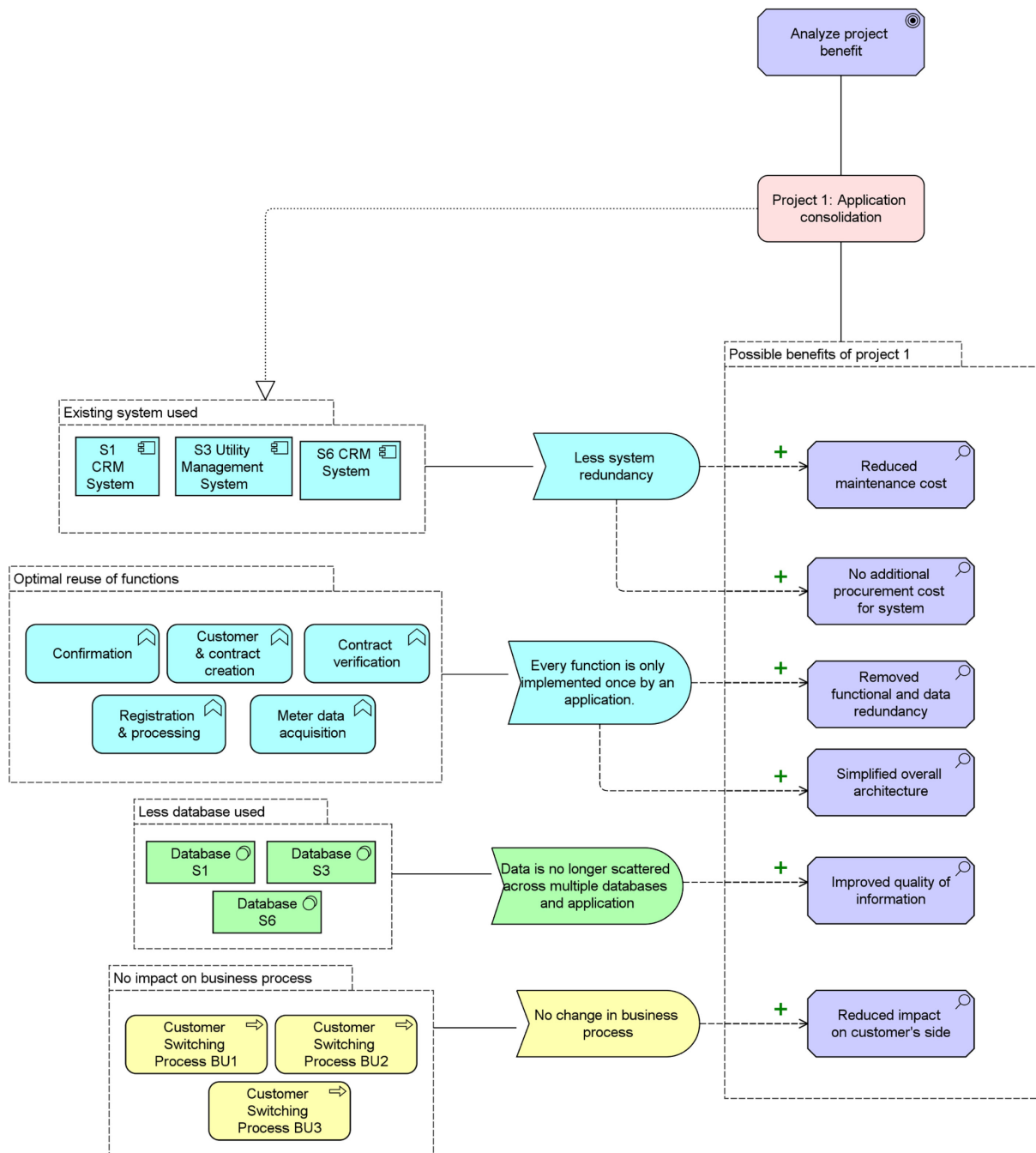


Figure 42 Benefit of EPS Application Consolidation Project

Once the benefits are identified, each of the benefit must be scored based on the associated importance level and impact for the organization. This could be done for example by conducting a workshop with relevant decision makers and they can decide the level of

importance and impact for each identified benefit. One example of benefit importance level that can be used is presented in the table below.

*Table 30 Benefit Importance Level*

Element	Score	Description
<b>Benefit score</b>	1	Very Low Importance
	2	Low Importance
	3	Moderate Importance
	4	High Importance
	5	Very High Importance

It is also possible to use financial measurement techniques to evaluate the overall project benefit. Also, incorporating the monetary value and assigning this value to importance level scale is also another possible way to assess benefit. Regardless of the assessment techniques, what is critical to note is the value must be higher if the benefit of the project is considered better. This is necessary since the main objective of the next step is to maximize the benefit gained from the project.

*Table 31 EPS Application Consolidation Project Benefit Analysis*

No	Identified Benefit	Score
<b>1</b>	Reduced maintenance cost	4
<b>2</b>	No additional procurement cost	3
<b>3</b>	Removed functional and data redundancy	5
<b>4</b>	Simplified architecture	4
<b>5</b>	Improved quality of information	4
<b>6</b>	Reduced impact on customers	5
	Total Project Benefit (Average)	4.5

From the calculation, we can sum up that from all the identified benefits, the overall score of benefit for the application consolidation project in EPS is 4.5. This result means that the identified benefits are considered important for EPS and are considered to have big impact or high value in solving the problem of customer satisfaction. This information will later be used for comparing the possible projects, along with other criteria as well, which will be explained in more detail in the next section.

The benefit analysis will be performed for each of the possible projects that want to be assessed, similar to other project-specific analysis. When all the possible projects have been analyzed and benefit score for all projects have been determined, then the final project selection could be performed, as explained in the next section.

#### 4.2.8 Step 8: Project Selection Analysis

As explained in Chapter 3, the last step in the proposed method is to select the best projects based on the criteria and analysis performed in previous steps. For the final project selection analysis, a linear programming model called DEA will be used. Before conducting the analysis, the information on the possible project that will be assessed must be prepared in advance. This information includes data about the project as a result of the previous analyses, which are expected project cost, project risk score, expected benefit score, and impact on capability improvement score. For the EPS case, the capability that will be the main focus is “Customer Relation Management” capability, as a result of project impact analysis in Step 3. In addition, other project information such as expected implementation time will be needed as one of the criteria for project selection analysis. In summary, the main goal of the analysis is to minimize the cost, time required, and risk, while maximizing the project benefit and capability improvement, as modelled in Figure 43 below.

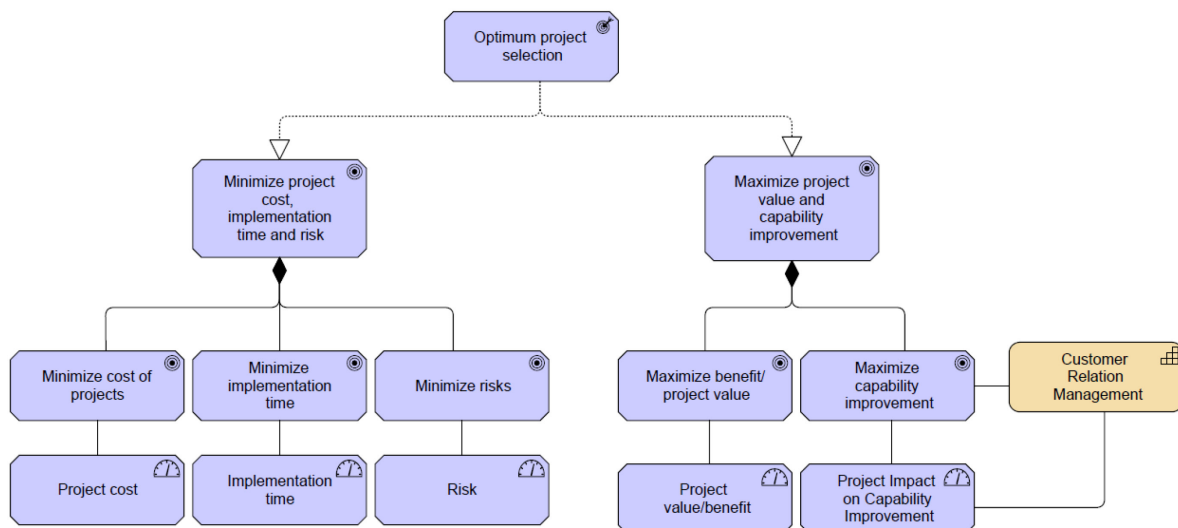


Figure 43 EPS Project Selection Analysis, modelled with ArchiMate

The next step is to populate the data of the possible projects. In this case, the project that was analyzed in detail is the application consolidation project. However, for the sake of applying the DEA model, several projects must be considered for the analysis. Since it is often mentioned in the literature that the number of units in DEA must be more than the number of input and output, we assumed that there are five other possible projects as part of the proposal. Project 1 refers to the application consolidation project, thus the data for this project is already available as a result of the previous analyses. The data for the rest of the projects are made based on assumptions. Summary of the populated data that will be used for the DEA calculation is presented in the table below.

Table 32 EPS Project Data Population

Projects	Cost of projects (million euro)	Implementation time (weeks)	Risk scale (1-4) (low to high)	Benefit (importance level)	Impact on capability (weighted score from AHP)
Project 1	10	35	2	5	0,29
Project 2	16,5	35	2	4	0,23
Project 3	8	55	2	3	0,16
Project 4	17	32	3	2	0,08
Project 5	12	62	4	4	0,18
Project 6	9,5	55	3	2	0,06

First, the information about the expected project cost is obtained from the result of step 5 or the benefit analysis step. Data about project implementation time was made based on assumptions but this data is usually available in a project proposal. Next, the risk score for each project is acquired from the output of the risk analysis in step 6. Similarly, the benefit score is also retrieved from the outcome of the sixth step i.e. benefit analysis. Lastly, the impact of project on capability improvement is obtained from the result of the AHP method performed in the third step of the approach. In this case, the score refers to the impact of the project with regards to 'Customer Relation Management' capability, as a result of the first step. As explained earlier, it is possible to have more than one capability to focus on. If there is more than one capability to be considered, one output should be added in the data for DEA calculation to represent the impact of each project to the specified capability.

Once all the data is populated, the DEA calculation using a software is performed to analyze the populated data. As mentioned in the previous chapter, DEA Frontier software is used for the DEA calculation. Based on the data presented in Table 30, the DEA calculation is performed. Based on these data, the efficiency score result for all the projects shown by the software is presented in the table below.

Table 33 DEA Calculation Result

DMU No.	DMU Name	Efficiency
1	Project 1	1,00000
2	Project 2	0,80000
3	Project 3	0,75000
4	Project 4	0,43750
5	Project 5	0,66667
6	Project 6	0,42105

As can be seen from the DEA calculation result, project 1 has the highest efficiency score, followed by project 2, project 3, project 5, project 4, and lastly project 6. This means,

considering the given input and output presented in Table 5, project 1 is most likely to achieve maximum output while minimizing cost, implementation time, and risk. In addition to the efficiency score, the software also provides slack analysis result of the DEA calculation, as presented in Table 32 below. The slack analysis enables the user to analyze the result in more depth and give the users the reasoning why other projects are considered inefficient or less efficient.

Table 34 Slack Analysis EPS

DMU No.	DMU Name	Input Slacks			Output Slacks	
		Cost of projects (million euro)	Implementation time (weeks)	Risk scale (1-4) (low to high)	Benefit (importance level)	Impact on capability (AHP score)
1	Project 1	0,00000	0,00000	0,00000	0,00000	0,00000
2	Project 2	5,20000	0,00000	0,00000	0,00000	0,00200
3	Project 3	0,00000	20,25000	0,30000	0,00000	0,01400
4	Project 4	3,43750	0,00000	0,51250	0,00000	0,03600
5	Project 5	0,00000	13,33333	1,06667	0,00000	0,05200
6	Project 6	0,00000	9,15789	0,46316	0,00000	0,05600

As can be seen from the result of slack analysis, project 2 is considered less efficient mainly because of the input, which is the expected project cost. Moreover, project 3 and project 4 are considered less efficient mainly due to the implementation of time of the project, although project 4 also has slacks in other factors such as project cost and impact on capability. Other than that, project 5 is also considered inefficient due to its higher risk score. Thus, this analysis could also help the users to interpret the efficiency result and to evaluate what will happen to the efficiency score if they change the project data.

In summary, the results of the analysis from the previous steps are used as to perform the final project selection analysis. Detailed activities on how to perform each of the step in a case study of EPS company is explained in detail in this chapter. It starts from capability analysis based on EPS specific concern using the AHP method, EA-based analysis for project assessment, and lastly project selection analysis using the DEA method.

To conclude, the proposed method incorporates the result of capability analysis with the result of project assessment (i.e. project impact, cost, risk, and benefit) in order to determine which project to be selected by EPS in order to address their concern related to low customer satisfaction. Based on the method, it shows that EPS must focus on the 'Customer Relation Management' capability if they want to solve the problem of customer satisfaction. The method also helps EPS in determining the impact of project to capability improvement based on specified capability metrics. Moreover, using the EA-based modelling analysis, each project could be assessed and evaluated in order to determine the impact, expected cost, risk, and benefit. Finally, all of the information obtained from the analyses are used for the final project

selection analysis using the DEA method. The result of the DEA shows the score of the projects that EPS must select in order for them to address the problem of low customer satisfaction rating. The proposed method could help EPS to make sure the project to be selected will improve the performance of the capability and solve the concern EPS has in the first place, as the driver of implementing the project.

### *Sensitivity Analysis*

In order to further validate the result of the DEA method in the last step, sensitivity analysis is performed for the case study. Since the DEA method is based on linear programming model, the sensitivity analysis for DEA usually requires some mathematical model and theorem development. A lot of studies in the literature have performed a thorough sensitivity analysis for the DEA model available. Some studies performed sensitivity analysis in DEA by changing the value of some of the inputs and outputs simultaneously (Cooper, W. W. et al., 2001; Jahanshahloo et al., 2005; Seiford & Zhu, 1998; Zhu, 2001), while others focused on the number inputs and outputs (Noroozi & Sarfi, 2015). In summary, the results from the DEA sensitivity analysis were found to be robust with respect to efficiency score of the unit when DEA was applied to the data in the analysis.

In this research, we will use what-if scenarios that are applied to the value of the input and output data in the DEA method. The input and output data are slightly modified in order to observe the impact on the results, which in this case the efficiency score of the project.

To simplify the analysis, only one input and one output data are selected as the basis for the what if-scenarios. Cost of project and capability score are selected to be the changing variable for input and output sensitivity analysis, respectively. The result of the sensitivity analysis will show how the efficiency score of the project will change if the value of the input or output data changes. Thus, one project to be analyzed must be chosen for the analysis.

Since we want to analyze how the efficiency score changes, project that has the lowest efficiency score is chosen, i.e. Project 6. Thus, the goal of the what-if scenarios is to see how much the value of input and output should be changed in order for Project 6 to be considered efficient. For input sensitivity analysis, 2-main scenarios are analyzed, in which one scenario does not have any relation with the output and the other one is relative to output changes. Each of this main scenario will have sub-scenarios where the value of the input is gradually changed. Summary of the scenarios used for input sensitivity analysis is provided in the Table 35 below.

*Table 35 Scenario for Input Sensitivity Analysis*

Scenario	Description	Sub-Scenario
1	Capability score remains the same	a) Cost decreased by 0.5 million b) Cost decreased by 1 million c) Cost decreased by 1.5 million d) Cost decreased by 2 million e) Cost decreased by 2.5 million

<b>2</b>	Capability score increased by 0.25	<ul style="list-style-type: none"> <li>a) Cost decreased by 0.5 million</li> <li>b) Cost decreased by 1 million</li> <li>c) Cost decreased by 1.5 million</li> <li>d) Cost decreased by 2 million</li> <li>e) Cost decreased by 2.5 million</li> </ul>
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The same rules applied for the output sensitivity analysis. In this case, we want to analyze how much the output data, i.e. the capability score, should be changed in order for the project to be efficient. In the third scenario, all of the input data remain the same and changes are only occurred for capability score as depicted in the sub-scenario. Meanwhile in scenario 4, the cost of project is decreased to see how is the impact to the efficiency score relative to the change of input data. The scenarios and sub-scenarios used for the output sensitivity analysis is summarized in the table below.

*Table 36 Scenario for Output Sensitivity Analysis*

<b>Scenario</b>	<b>Description</b>	<b>Sub-Scenario</b>
<b>3</b>	Cost of project remains the same	<ul style="list-style-type: none"> <li>a) Capability score increased by 0.05</li> <li>b) Capability score increased by 0.1</li> <li>c) Capability score increased by 0.15</li> <li>d) Capability score increased by 0.2</li> <li>e) Capability score increased by 0.25</li> </ul>
<b>4</b>	Cost of project decreased by 2.5 million	<ul style="list-style-type: none"> <li>a) Capability score increased by 0.05</li> <li>b) Capability score increased by 0.1</li> <li>c) Capability score increased by 0.15</li> <li>d) Capability score increased by 0.2</li> <li>e) Capability score increased by 0.25</li> </ul>

In total, there are 20 different scenarios that are analyzed for sensitivity analysis purpose, 10 for each input and output sensitivity analysis. It is important to note that the value of input and output for other projects remain the same. Thus, the shift in the efficiency score of one inefficient project is the main focus in this analysis.

Once the scenarios are defined, next step is to run the DEA software for each of the scenario. This is necessary since the efficiency score for the project is obtained from calculation in the software. Other parameters such as the DEA model type and orientation of the model must be kept unchanged when performing the calculation repeatedly. After the calculation for all the scenarios are done, we can analyze the difference in the efficiency score of the project with regards to the defined scenario. Firstly, we will analyze the input sensitivity analysis, with scenario 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 2d, and 2e as the basis. The result of the input sensitivity analysis is shown in Figure 44 below.



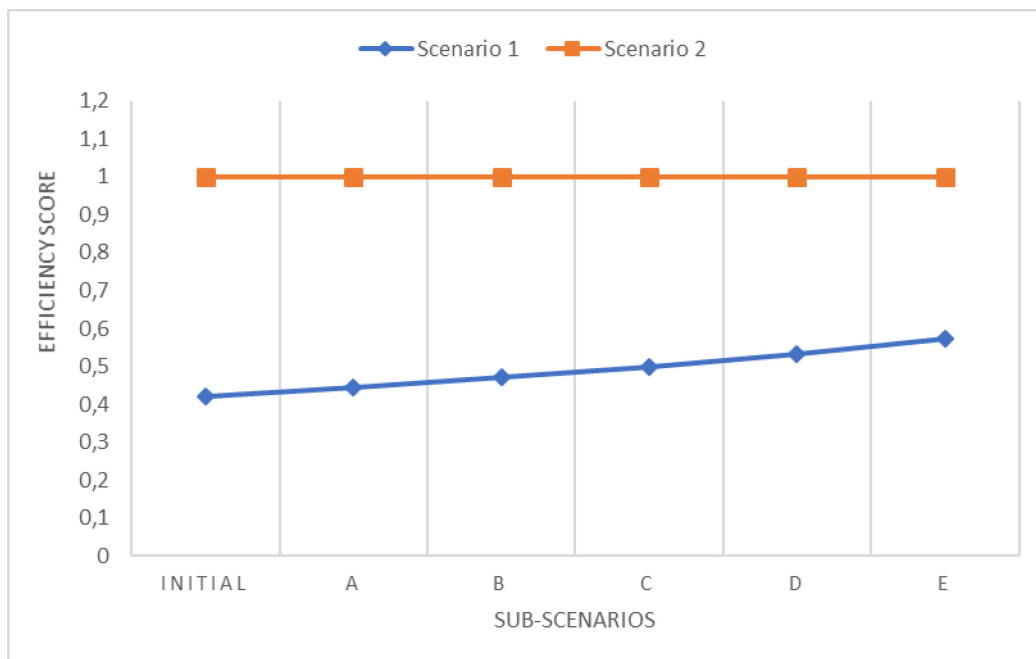


Figure 44 Input Sensitivity Analysis Result

The result of the shows the efficiency score for the project is gradually increasing when the cost of the project decreased. In scenario 1, where there is no change in the capability score, even though the efficiency score increased, it still does not reach 1. The highest score was achieved when the cost is decreased by 2.5 million, with 0.57 as the efficiency score. This means that the efficiency score is increased only by 0.15 point. Thus, even though the cost of the project is lower, it is still considered as a not efficient project due to the fact it still has low output.

On the other hand, the result of analysis for scenario 2 turned out to be completely different. In scenario 2, change in the output variable was added, which is the increase of capability score by 0.25 point, while at the same time the cost of project keeps decreasing. As can be seen in the figure above, the increase of the output variable highly influenced the efficiency score. Even when there is no change made to the input, the efficiency score of the project could reach 1 point, which means the project is considered efficient with regards to its input and output. When the value of the cost keeps increasing, the efficiency score remains at its peak, which is in 1 point. It is depicted in the score for all the sub-scenarios of scenario 2 i.e. 2a, 2b, 2c, 2d, and 2e, where all these scenarios are resulting in 1 efficiency score. This means that there are many possible conditions that allow this project to achieve the highest efficiency score, meaning that it could be the best project to be chosen. Thus, it is also possible to have more than one projects that have 1 efficiency score, or the highest efficient projects.

This result is expected to happen since for the efficiency calculation, we use the trial version of the DEA software. Thus, the DEA models available in the trial version are limited to standard model only. As explained in previous section, for this research standard Envelopment model was applied for calculation of the score. In the standard model, it is indeed possible to have more than one units to be considered efficient. However, if the original software was used,

super-efficiency model could be chosen for the DEA calculation. Super-efficiency DEA model differs from the standard model since it can provide efficiency ranking of the units evaluated in the DEA calculation. Thus, this model could be used when there are constraints that only one project must be selected or in ranking the efficiency of the proposed projects.

As for the output sensitivity analysis, the result is slightly different compared to the input sensitivity analysis. For the output sensitivity analysis, we can see that the increase in the efficiency score is somewhat larger when compared to the increase in input sensitivity analysis. As previously explained, there are 10 scenarios in total for the output sensitivity analysis, which can be seen in Table. The result of the sensitivity analysis for each of this scenario is depicted in Figure 45 below.

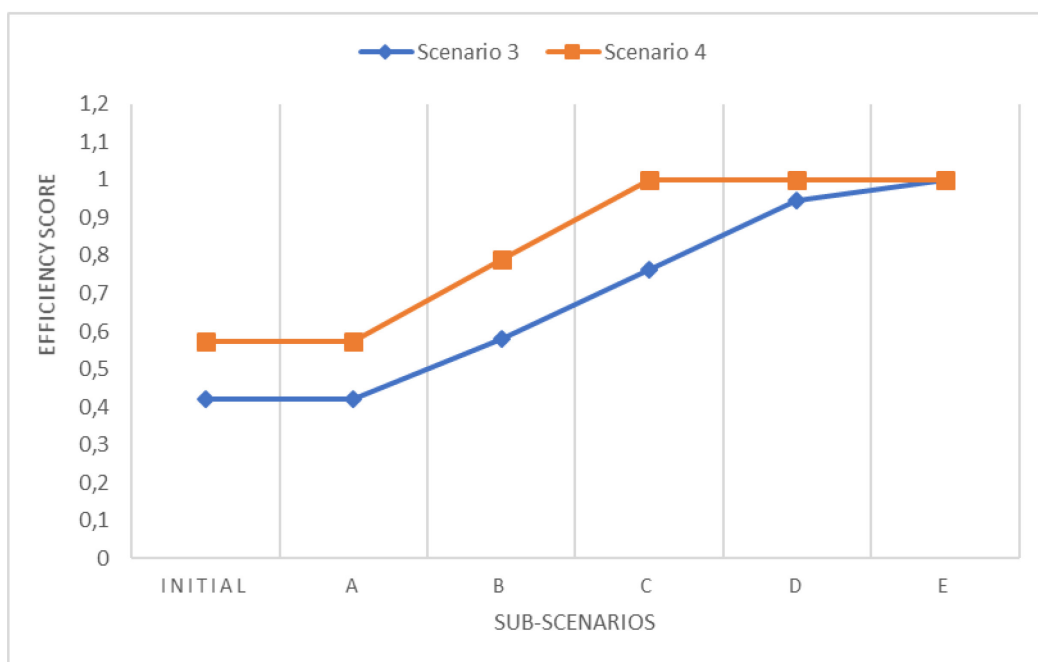


Figure 45 Output Sensitivity Analysis Results

As explained before, scenario 3 is when the input value or the cost of project remains the same while scenario 4 is applied with 2.5 million increases of the project cost. As can be seen in the picture above, the pattern of the increment for both scenario 3 and 4 are quite similar. With regards to the sub-scenarios, it is also shown in the result that for scenario 3a and 4b, the efficiency score does not increase at all. This means the rise of only 0.05 point in the capability score does not have any impact on the project efficiency score. Other than sub-scenario 3a and 3b, the rest of the scenarios have significant increases in the efficiency score value. It is also noteworthy to point out that in the case of scenario 3e, where the input value is unchanged, the efficiency of the project could go up to the highest point with just the increment of the capability score by 0.25 point.

The reason of this is due to the different range of the values for capability score and cost of project. For the cost of project, the value for other projects ranges from 8 to 16.5 million, while the capability score only ranges from 0.06 to 0.29 point. This justified the result why the

increase of 2.5 million for the cost only (scenario 1e) is not sufficient to achieve the maximum efficiency. On the other hand, the increase of 0.25 point in the capability score (scenario 3e) has big impact for the project to be considered efficient. This could also be justified by the fact that the highest capability score amongst all other projects is only 0.29 point, which is why the increase of 0.25 is considered very influential to achieve the highest project efficiency score.

## 5 Evaluation

In this chapter, the evaluation process regarding the implementation of the proposed method in the demonstration process will be described in detail. As explained in the previous chapter, this study refers to the design science research methodology (DSRM), and evaluation process is one of the essential step in DSRM. The evaluation process is expected to measure the quality of the proposed approach towards supporting specific objective.

Moreover, the evaluation process was done by performing a small workshop consists of five people from an organization. In this workshop, the use of the proposed approach into the case study will be presented by the researcher of this study. In the end of the workshop, each of the participant was asked to fill in a survey as part of evaluating the method and as feedback for the researcher. More explanation about the survey is provided in the next section, followed by the summary of the survey results in section 5.2.

### 5.1 Survey

As explained before, a survey is carried out with the purpose to evaluate the method and to receive some feedback regarding the proposed method. This survey is considered as a qualitative analysis, as it aims to collect the subjective judgment from the experts, which in this case are the practitioners from the related industry.

In order to formulate the questions and statements for the survey, we adopted the concept of Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2003). UTAUT is considered suitable in this study as it explains the distinct aspects towards user behavior and acceptance of the information technology.

UTAUT concept consists of several constructs that have significant role in determining user acceptance and usage behavior. Those constructs are performance expectancy, effort expectancy, social influence, and facilitating conditions, as can be found in Figure 46. This figure also shows additional factors that play the role as moderators towards user acceptance, such as gender, age, experience, and voluntariness of use. As these constructs are considered as indirect determinants of intention, these aspects will not be included in this study.

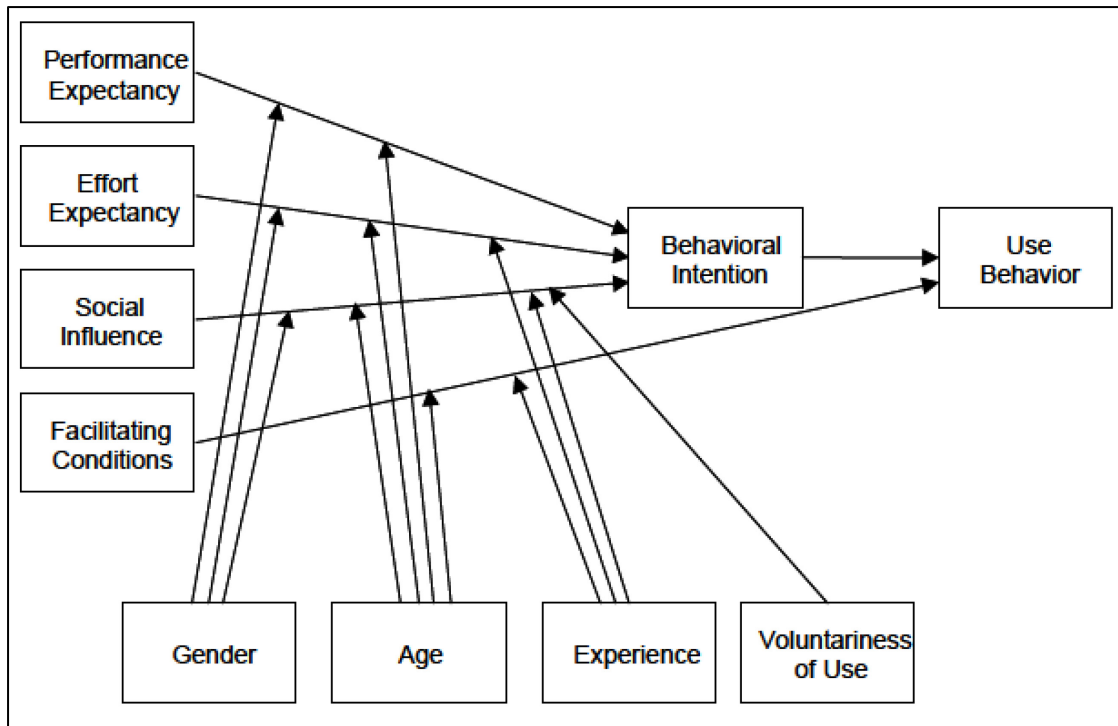


Figure 46 UTAUT Research Model (Venkatesh et al., 2003)

In their research, (Venkatesh et al., 2003) summarize their findings in a list of items that consists of eight main constructs with 31 items. These items that are considered as important elements in estimating the UTAUT were explained in Appendix 8. Table 37 below presents six items from this list that are used further to formulate our survey statements.

Table 37 List of constructs for estimating UTAUT (Venkatesh et al., 2003)

Construct	Definition	Items	Root Constructs
<b>Performance Expectancy</b>	The degree to which an individual believes that using the system will help him or her to attain gains in job performance.	U6: I would find the system useful in my job. RA1: Using the system enables me to accomplish tasks more quickly. RA5: Using the system increases my productivity. OE7: If I use the system, I will increase my chances of getting a raise.	Perceived usefulness (TAM/TAM2 and C-TAM-TPB), extrinsic motivation (MM), job-fit (MPCU), relative advantage (IDT), and outcome expectations (SCT)
<b>Effort Expectancy</b>	The degree of ease associated with the use of the system	EOU3: My interaction with the system would be clear and understandable. EOU5: It would be easy for me to become skillful at using the system. EOU6: I would find the system easy to use.	Perceived ease of use (TAM/TAM2), complexity (MPCU), and ease of use (IDT).

		EU4: Learning to operate the system is easy for me.	
<b>Facilitating Conditions</b>	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system	PBC2: I have the resources necessary to use the system. PBC3: I have the knowledge necessary to use the system. PBC5: The system is not compatible with other systems I use. FC3: A specific person (or group) is available for assistance with system difficulties.	Perceived behavioral control (TPB/ DTPB, C-TAM-TPB), facilitating conditions (MPCU), and compatibility (IDT)
<b>Attitude towards Using Technology</b>	An individual's overall affective reaction to using a system	A1: Using the system is a bad/good idea. AF1: The system makes work more interesting. AF2: Working with the system is fun.	Attitude toward behavior (TRA, TPB/DTPB, C-TAMTPB), Intrinsic motivation (MM), Affect toward use (MPCU), and Affect (SCT)
<b>Self-efficacy</b>	Judgment of one's ability to use a technology (e.g., computer) to accomplish a particular job or task	I could complete a job or task using the system... SE1: If there was no one around to tell me what to do as I go. SE4: If I could call someone for help if I got stuck. SE6: If I had a lot of time to complete the job for which the software was provided. SE7: If I had just the built-in help facility for assistance.	Self-efficacy (SCT)
<b>Behavioral Intention to Use</b>	A person's perceived likelihood or subjective probability that he or she will engage in a given behavior	BI1: I intend to use the system in the next <n> months. BI2: I predict I would use the system in the next <n> months. BI3: I plan to use the system in the next <n> months.	Attitude Toward Behavior (TRA, TPB/DTPB, C-TAMTPB), Perceived behavioral control (TPB/ DTPB, CTAM-TPB), Intrinsic motivation (MM)

## 5.2 Workshop Result

As explained in the introduction of this chapter, a small workshop has been performed in order to evaluate the proposed method in this research. This workshop took place in BiZZdesign company. In the end of the workshop, participants were requested to fill in a small survey regarding the proposed method.

The data analysis provides valuable insights about the study. In the evaluation, we start by asking three background questions about the participants' role in the organization, the frequency of using the quantitative analysis and EA-based modelling analysis. In addition, six aspects of the UTAUT constructs which include performance expectancy, effort expectancy, attitude towards using technology, facilitating condition, self-efficacy, and behavioral intention to use the system were also asked in the survey. The analysis of the result regarding the background questions and each of its aspect will be discussed in detail as follows:

### **Q1: What is your current position/ role in your organization?**

The participants of the workshop consist of five experts from BiZZdesign company. It consists of two research consultants and three customer success consultants. This thesis is performed under the research and development department of BiZZdesign, hence some of the participants are the research consultants. Moreover, three participants are part of customer success consultants that help customers obtaining maximum business value from the tools provided by BiZZdesign. Thus, it is also important to evaluate the proposed method from the perspective of how the method could bring additional value to customers of BiZZdesign.

### **Q2: How often do you use EA-based analysis as part of your job?**

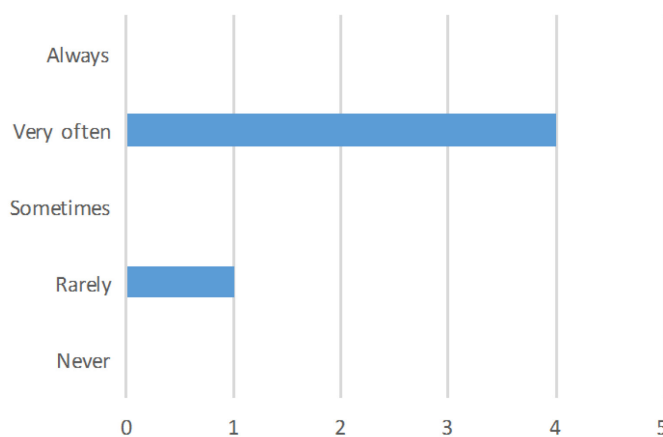


Figure 47 Frequency of using EA-based analysis

As can be seen in the Figure 47, four out of five participants use EA-based analysis very often as part of their daily job. This includes all of the three customer success consultants and one research consultant. Moreover, only one participant stated that EA-based analysis is rarely used.

In general, it can be concluded that EA-based analysis is not something new in BiZZdesign and we can say that all participants have used it at least once as part of their job. This result is not surprising since BiZZdesign is recognized as a leader company in the Enterprise Architecture area with their EA tools as the key element of the company.

**Q3: How often do you use analytical Multi Criteria Decision Analysis (MCDA) methods as part of your job?**

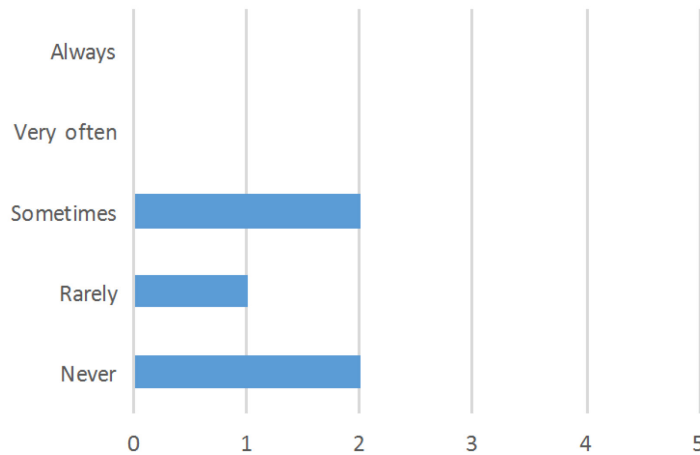


Figure 48 Frequency of using MCDA methods

Different from the previous question, the frequency of using MCDA methods as part of the job is quite vary based on the survey result. Only two participants said that they sometimes use MCDA methods. On top of that, one participant rarely uses the method and even two participants stated that they never use MCDA methods at all. What is interesting is the participants who never use MCDA methods are both research consultants. Whereas the customer success consultant is either use it sometimes or rarely use it. However, comparing to EA-based analysis, the response for the MCDA methods is rather more in the negative scale, which implies that the participants are less familiar with using the MCDA methods.

*Six Aspects from the UTAUT*

In this section, the results of the survey regarding the six aspects from the UTAUT model will be discussed in detail. As mentioned earlier, the questions for this part are related to the user acceptance of the proposed method. First of all, descriptive statistics of the survey will be presented in order to describe the basic features of the data and to summarize collection of information from the survey. The descriptive statistics for the survey data is depicted in Table 38 below. Some measures in the descriptive statistics table that will be used to describe a data set are explained as follows:

- o N refers to number of participants.
- o Min refers to the minimum value that is filled in by the participant for each statement.
- o Max refers to the maximum value that is filled in by the participant for each statement.
- o Sum refers to the total of values filled in by all participant for each statement.



- o Mean refers to the average of total values filled in by all participant for each statement.
- o STDEV refers to the standard deviation that is used to measure the dispersion, which refers to the spread of the values around the central tendency. The larger the standard deviation is, the more dispersed the result will be.

Table 38 Descriptive Statistics of the Survey

Question	N	Min	Max	Sum	Mean	STDEV
PE-1	5	3	5	20	4	0.707106781
PE-2	5	2	3	13	2.6	0.547722558
PE-3	5	2	4	16	3.2	0.836660027
EE-1	5	2	5	15	3	1.224744871
EE-2	5	3	4	18	3.6	0.547722558
EE-3	5	3	4	19	3.8	0.447213595
FC-1	5	2	5	16	3.2	1.095445115
FC-2	5	3	5	20	4	0.707106781
FC-3	5	4	5	22	4.4	0.547722558
ATT-1	5	4	5	21	4.2	0.447213595
ATT-2	5	2	5	18	3.6	1.140175425
ATT-3	5	3	5	20	4	0.707106781
SE-1	5	3	5	21	4.2	0.836660027
SE-2	5	3	5	20	4	0.707106781
BIU-1	5	3	4	19	3.8	0.447213595
BIU-2	5	2	4	16	3.2	0.836660027
BIU-3	5	3	4	19	3.8	0.447213595
<b>Average PE</b>	-	2.33	4	16.33	3.27	0.69716312
<b>Average EE</b>	-	2.67	4.33	17.33	3.47	0.73989367
<b>Average FC</b>	-	3	5	19.33	3.87	0.78342482
<b>Average ATT</b>	-	3	5	19.67	3.93	0.76483193
<b>Average SE</b>	-	3	5	20.5	4.1	0.77188340
<b>Average BIU</b>	-	2.67	4	18	3.6	0.57702907

As the scoring refers to the five-level Likert scale, possible answers for the survey include strongly disagree, disagree, neutral, agree, and strongly agree. Each of this answer will be converted to a specific value ranging from one to five based on the scale. Thus, any values between one and two mean negative feedbacks, while three means the response is neutral, and four and five mean the feedback is positive. In summary, the higher the value means the feedback is more positive, with five being the highest value.

The measure of mean and standard deviation of the result are chosen to be the main focus for the analysis. Mean, or also known as the average, is useful in determining the overall trend of a data set or providing a rapid depiction of the data. On the other hand, standard deviation is considered useful for quickly determining dispersion of data points in the results. Summary

of the mean and standard deviation for all aspects in the questionnaire is depicted in Figure 49.

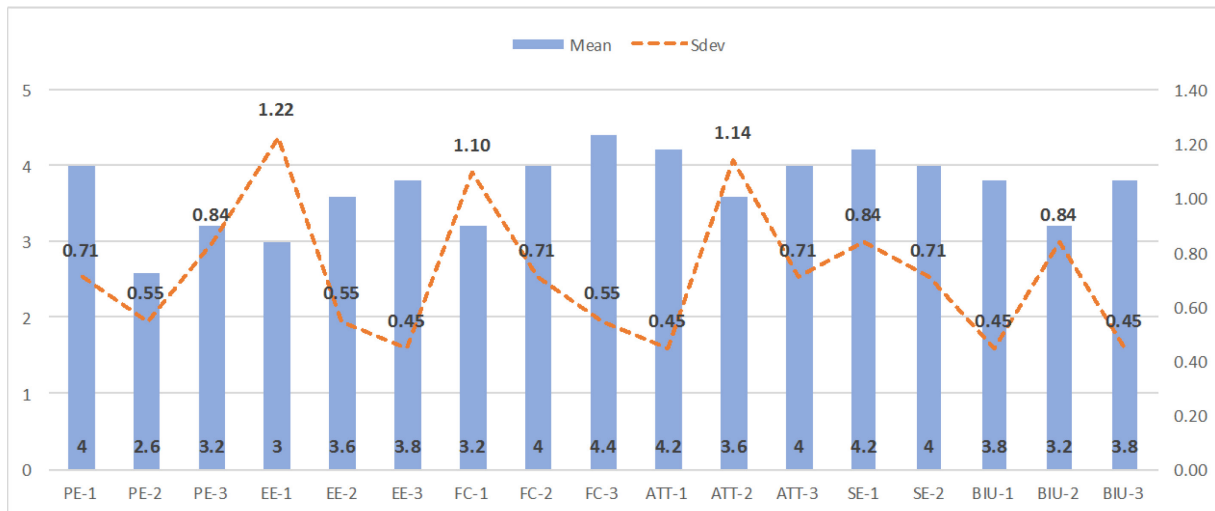


Figure 49 Mean and Standard Deviation Summary

As we can see in the above figure, the mean value for each question ranges from 2.8 to 4.4. The mean value for most of the questions are above 3.2, which means that the feedbacks given by the participants are positive. This implies that in general the participants of the survey have positive acceptance towards the proposed method. This is supported by the fact that only one question has a mean value that falls below 3. The most positive feedback is given for FC-3 and the most negative feedback is given for PE-2. This statement will be explained further in the discussion for each aspect of the UTAUT model.

From standard deviation's point of view, for some questions there are some amount of variation in the group. From all the questions, only three questions have standard deviation value above 1, which means the responses are not very dispersed. High value of standard deviation does not necessarily mean a bad thing; it just shows the values of the respond from the participants in the data set are farther away from the mean. Question EE-1 has the highest value of standard deviation compared to the rest of the questions, while the lowest value belongs to several questions. Detail analysis on the dispersion of the data for each of the UTAUT construct will be explained in the next section.

- o Performance Expectancy

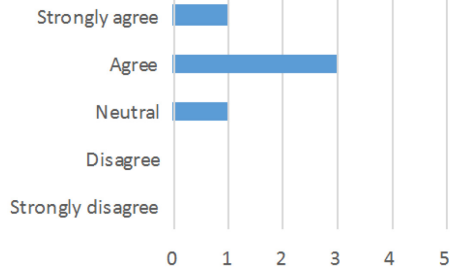
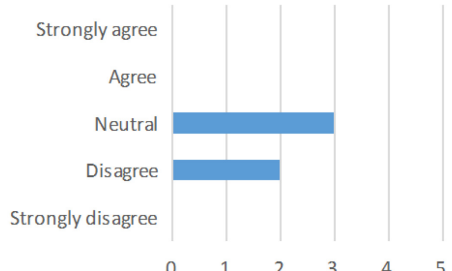
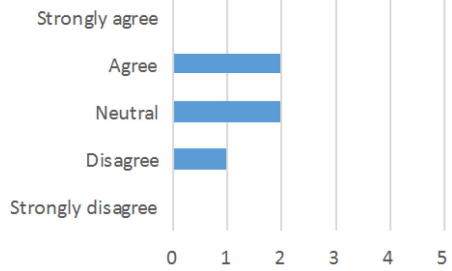
Table 39 below shows the result of the questions regarding performance expectancy of the method. Based on the table it can be seen that most of the participants agree that they want to use the proposed method since it is considered helpful.

On the contrary, the responses vary between neutral and disagree when they were asked if the method would enable them in accomplishing tasks more quickly. This question has the most negative responses from the participants compared to all the other questions in the survey. This could be due to the steps that must be performed in the method. In total, there are eight steps that must be performed in the proposed method, with some additional loops

in the steps if there are more than one chosen capability. Additionally, the steps that are related to project assessment must be done for each project before performing the final project selection analysis. It could be assumed that extra time is required in order to gather all data needed and to perform all of the steps in the method. Thus, it is reasonable if some the participants think that using the proposed method will not help them to accomplish tasks more quickly.

In addition, the participants have a dispersed opinion on whether the method would increase their productivities. One participant disagrees with this statement, two participants have unbiased opinion, while the other two agrees that the method will increase the productivity of their jobs. In summary, it can be concluded that most of the participants have positive feedback regarding the performance expectancy of the method, except for the question related to accomplishing tasks more quickly. The most important thing is the participants found the method to be useful and will help them in their job, even though it is not necessarily quicker.

Table 39 Performance Expectancy Survey Result

Construct	Question	Result												
Performance Expectancy	I would like to use the proposed method as it is considered helpful	 <table border="1"> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>3</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	1	Agree	3	Neutral	1	Disagree	0	Strongly disagree	0
	Response	Count												
	Strongly agree	1												
Agree	3													
Neutral	1													
Disagree	0													
Strongly disagree	0													
Using the proposed method enables me to accomplish tasks more quickly	 <table border="1"> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>0</td> </tr> <tr> <td>Agree</td> <td>0</td> </tr> <tr> <td>Neutral</td> <td>3</td> </tr> <tr> <td>Disagree</td> <td>2</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	0	Agree	0	Neutral	3	Disagree	2	Strongly disagree	0	
Response	Count													
Strongly agree	0													
Agree	0													
Neutral	3													
Disagree	2													
Strongly disagree	0													
Using the proposed method increases my productivity	 <table border="1"> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>0</td> </tr> <tr> <td>Agree</td> <td>2</td> </tr> <tr> <td>Neutral</td> <td>2</td> </tr> <tr> <td>Disagree</td> <td>1</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	0	Agree	2	Neutral	2	Disagree	1	Strongly disagree	0	
Response	Count													
Strongly agree	0													
Agree	2													
Neutral	2													
Disagree	1													
Strongly disagree	0													

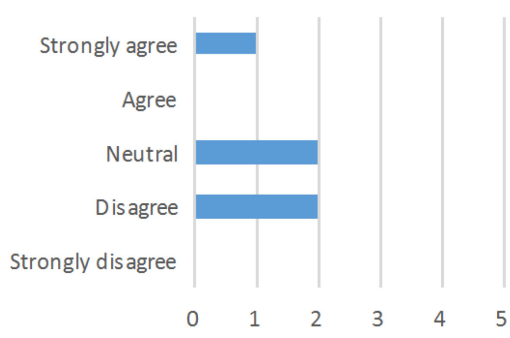
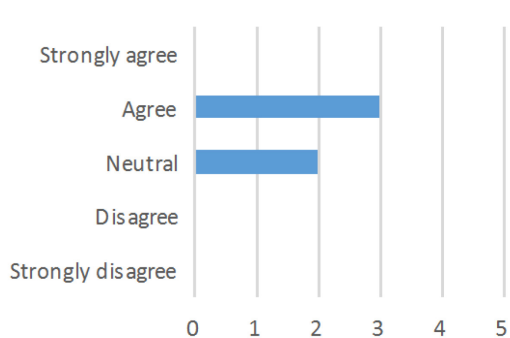
o Effort Expectancy

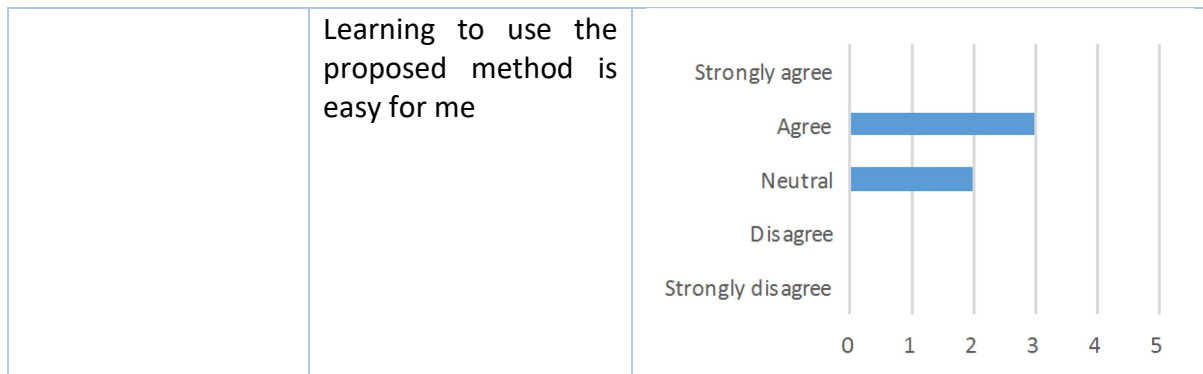
For this part, the questions were meant to evaluate the easiness of the proposed method. As can be seen in table, participants have different opinion on whether using the proposed method is easy. The possible reason that several participants give a neutral answer or somewhat disagree with the statement that using the method is easy might be because they are not familiar with some of the methods used in the proposed method, especially the AHP method and the DEA model. It is also supported by the fact that most of the participants never use the MCDA methods in part of their job, as stated in the questions related to background information. Thus, it is possible that for some of the participants, the analysis techniques used in the method (e.g. AHP and DEA) look very complicated at the first glance.

However, the participants show positive feedback on the rest of the questions related to effort expectancy. Most of the participants agree that their interaction with the method will be clear and understandable. Moreover, most of the participants also agree that it will be easy for them to learn how to use the proposed method. It is important to note that two participants have neutral opinion regarding this, which might also due to the presence of some mathematical techniques for the analysis in the method.

In conclusion, the result implies that for effort expectancy, even though it might be not easy to use the method for the first time, it will be easy for the participants to learn the method and get familiar with the proposed method.

Table 40 Effort Expectancy Survey Result

Construct	Question	Result												
Effort Expectancy	I would find the proposed method easy to use	 <table border="1"> <caption>Data for 'I would find the proposed method easy to use'</caption> <thead> <tr> <th>Response Category</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>0</td> </tr> <tr> <td>Neutral</td> <td>2</td> </tr> <tr> <td>Disagree</td> <td>2</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response Category	Count	Strongly agree	1	Agree	0	Neutral	2	Disagree	2	Strongly disagree	0
	Response Category	Count												
Strongly agree	1													
Agree	0													
Neutral	2													
Disagree	2													
Strongly disagree	0													
	My interaction with the proposed method will be clear and understandable	 <table border="1"> <caption>Data for 'My interaction with the proposed method will be clear and understandable'</caption> <thead> <tr> <th>Response Category</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>0</td> </tr> <tr> <td>Agree</td> <td>3</td> </tr> <tr> <td>Neutral</td> <td>2</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response Category	Count	Strongly agree	0	Agree	3	Neutral	2	Disagree	0	Strongly disagree	0
Response Category	Count													
Strongly agree	0													
Agree	3													
Neutral	2													
Disagree	0													
Strongly disagree	0													



o Facilitating Conditions

The table below shows the result of questions related to facilitating conditions when using the proposed method. Based on the table, it can be seen that the result is quite dispersed even though it leans more on the positive side. For the statement about whether they have the resource necessary, one participant disagrees with the statement, one participant strongly agrees, while the rest give neutral response. The neutral and negative response for this statement might be because the tools for the analysis that is not available for the participants. Other reason might be some of the participants do not have to use business analysis as part of their job, in which resulting in lack of resource necessary for using the proposed method.

On the other hand, most of the participants agree that they have the knowledge required to use the method, which is considered important for the feasibility of using the method in the future. Moreover, all of the participants agree that the proposed method is compatible with the other systems they used as part of their job. The main reason is because all of the analyses in the proposed method are modelled using Enterprise Studio, which is the main tool used in BiZZdesign. In conclusion, the overall result shows a positive feedback regarding the facilitating conditions of the proposed method.

Table 41 Facilitating Conditions Survey Result

Construct	Question	Result												
Facilitating Conditions	I have the resource necessary to use the proposed method	<table border="1"> <caption>Data for 'I have the resource necessary to use the proposed method'</caption> <thead> <tr> <th>Response Category</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>0</td> </tr> <tr> <td>Neutral</td> <td>3</td> </tr> <tr> <td>Disagree</td> <td>1</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response Category	Count	Strongly agree	1	Agree	0	Neutral	3	Disagree	1	Strongly disagree	0
	Response Category	Count												
	Strongly agree	1												
Agree	0													
Neutral	3													
Disagree	1													
Strongly disagree	0													
I have the knowledge necessary to use the proposed method	<table border="1"> <caption>Data for 'I have the knowledge necessary to use the proposed method'</caption> <thead> <tr> <th>Response Category</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>3</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response Category	Count	Strongly agree	1	Agree	3	Neutral	1	Disagree	0	Strongly disagree	0	
Response Category	Count													
Strongly agree	1													
Agree	3													
Neutral	1													
Disagree	0													
Strongly disagree	0													
The proposed method is compatible with other systems or tools I use for my work	<table border="1"> <caption>Data for 'The proposed method is compatible with other systems or tools I use for my work'</caption> <thead> <tr> <th>Response Category</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>2</td> </tr> <tr> <td>Agree</td> <td>3</td> </tr> <tr> <td>Neutral</td> <td>0</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response Category	Count	Strongly agree	2	Agree	3	Neutral	0	Disagree	0	Strongly disagree	0	
Response Category	Count													
Strongly agree	2													
Agree	3													
Neutral	0													
Disagree	0													
Strongly disagree	0													

o Attitude Towards Technology

The survey result of the attitude toward using technology can be seen in Table 42 below. First of all, all of the participants agree that using the proposed method is a good idea. In fact, this statement receives the most positive feedback from the participants out of all the statements in the survey. This supported the other statement in where most participants agree that the method is considered useful.

However, the statement whether the method makes work more interesting have various response from the participants. It is assumed that this is because the statement is quite subjective and the definition of interesting for each person can vary. For example, to determine if a method is a good idea or not is rather simpler since it could be based on the performance of the method and whether it is useful or not for the participants.

In the end, based on the overall result the attitude toward using the proposed method has positive feedback from the participants.

Table 42 Attitude Towards Technology

Construct	Question	Result												
Attitude Towards Technology	Using the proposed method is a good idea	<table border="1"> <caption>Data for 'Using the proposed method is a good idea'</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>4</td> </tr> <tr> <td>Neutral</td> <td>0</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	1	Agree	4	Neutral	0	Disagree	0	Strongly disagree	0
Response	Count													
Strongly agree	1													
Agree	4													
Neutral	0													
Disagree	0													
Strongly disagree	0													
	The proposed method makes my work more interesting	<table border="1"> <caption>Data for 'The proposed method makes my work more interesting'</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>2</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>1</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	1	Agree	2	Neutral	1	Disagree	1	Strongly disagree	0
Response	Count													
Strongly agree	1													
Agree	2													
Neutral	1													
Disagree	1													
Strongly disagree	0													
	I look forward to those aspects of my job that require me to use the proposed method	<table border="1"> <caption>Data for 'I look forward to those aspects of my job that require me to use the proposed method'</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>3</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	1	Agree	3	Neutral	1	Disagree	0	Strongly disagree	0
Response	Count													
Strongly agree	1													
Agree	3													
Neutral	1													
Disagree	0													
Strongly disagree	0													

o Self-Efficacy

The next part of the survey is related to self-efficacy aspect of the proposed method, in which the result is presented in the table below. Out of all the aspects, self-efficacy has the most positive feedback from the participants. If we refer back to the descriptive statistics table, it shows that this category has the highest mean value of 4.1 compared to other aspects. Basically, this means that not even one participant gave negative feedback, even though one participant is still neutral in their opinion. Based on this result, most of the participants agree that that they would use the proposed method if they can get help when they are stuck and if a guidance is available. Thus, for this aspect, it can be concluded that the participants are willing to use the proposed method, especially if they can get help when facing any difficulties

in using the method. Moreover, it is considered necessary to provide a guidance for using the proposed method, as it will increase the willingness of the users to use the proposed method.

Table 43 Self Efficacy Survey Result

Construct	Question	Result												
Self-efficacy	I would use the proposed method if I could get a help from someone if I got stuck	<table border="1"> <caption>Data for Question 1: I would use the proposed method if I could get a help from someone if I got stuck</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>2</td> </tr> <tr> <td>Agree</td> <td>2</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	2	Agree	2	Neutral	1	Disagree	0	Strongly disagree	0
	Response	Count												
Strongly agree	2													
Agree	2													
Neutral	1													
Disagree	0													
Strongly disagree	0													
	I would use the proposed method if there is built-in guide for assistance	<table border="1"> <caption>Data for Question 2: I would use the proposed method if there is built-in guide for assistance</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>1</td> </tr> <tr> <td>Agree</td> <td>3</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	1	Agree	3	Neutral	1	Disagree	0	Strongly disagree	0
Response	Count													
Strongly agree	1													
Agree	3													
Neutral	1													
Disagree	0													
Strongly disagree	0													

o Behavioral Intention to Use

Regarding the intention to use the proposed method, the results that are presented in Table 44 below in general show positive feedback. Thus, we could say that most of the participants have the intention to use the proposed method in the future as part of their job or to deal with the customers. However, one participant disagrees with the statement to use the method in the future for the completion of their job.

The assumption regarding the reason behind this disagreement is that the role of the participant in the company is not really related to project portfolio management, hence the use of the method is considered not a priority for the participant. However, in summary, the intention to use the proposed method is still considered positive, as supported by the overall mean value of 3.6 for the ‘behavioral intention to use’ aspect, which is considered as a high value.



Table 44 Behavioral Intention to Use Survey Result

Construct	Question	Result												
Behavioral Intention to Use	I intend to use the proposed method in the future to help me completing my job	<table border="1"> <caption>Data for 'I intend to use the proposed method in the future to help me completing my job'</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>0</td> </tr> <tr> <td>Agree</td> <td>4</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	0	Agree	4	Neutral	1	Disagree	0	Strongly disagree	0
	Response	Count												
	Strongly agree	0												
Agree	4													
Neutral	1													
Disagree	0													
Strongly disagree	0													
I predict I would use the proposed method in the future to help me completing my job	<table border="1"> <caption>Data for 'I predict I would use the proposed method in the future to help me completing my job'</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>0</td> </tr> <tr> <td>Agree</td> <td>2</td> </tr> <tr> <td>Neutral</td> <td>2</td> </tr> <tr> <td>Disagree</td> <td>1</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	0	Agree	2	Neutral	2	Disagree	1	Strongly disagree	0	
Response	Count													
Strongly agree	0													
Agree	2													
Neutral	2													
Disagree	1													
Strongly disagree	0													
I plan to use the proposed method in the future for helping me when dealing with the clients	<table border="1"> <caption>Data for 'I plan to use the proposed method in the future for helping me when dealing with the clients'</caption> <thead> <tr> <th>Response</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>Strongly agree</td> <td>0</td> </tr> <tr> <td>Agree</td> <td>4</td> </tr> <tr> <td>Neutral</td> <td>1</td> </tr> <tr> <td>Disagree</td> <td>0</td> </tr> <tr> <td>Strongly disagree</td> <td>0</td> </tr> </tbody> </table>	Response	Count	Strongly agree	0	Agree	4	Neutral	1	Disagree	0	Strongly disagree	0	
Response	Count													
Strongly agree	0													
Agree	4													
Neutral	1													
Disagree	0													
Strongly disagree	0													

In the end, we can conclude that in general the participants gave a positive feedback for majority of the aspects of UTAUT model, which includes performance expectancy, effort expectancy, attitude towards technology, self-efficacy, facilitating conditions, and behavioral intention to use. The lowest score falls to the aspect of effort expectancy, which is assumed is due to the analytical techniques used in the proposed method. Moreover, the result shows the most positive feedback for self-efficacy, which means that the participants are highly willing to use the method, especially with some guidelines to support the use of the method. Overall, the participants show high acceptance the proposed method which implies that the method is considered to be useful for the participants, which are the practitioners in the industry.

## 6 Conclusion

This chapter describes various aspects regarding the research, which is presented in this thesis. In the beginning, the conclusions based on the results of conducting a systematic literature review, applying a case study, and performing the evaluation will be discussed in the first section of the chapter. Then, the contributions presented as the result of this study will be provided in the second section. The last part of this chapter describes the limitations of the research, which is followed by the recommendations for further studies and for development in practice.

### 6.1 Discussion & Summary

The objective of this research is to design a method that includes analysis tools for project selection that integrates the concept of CBP and PPM. Consequently, this objective is depicted in the scope of this research which is derived from the formulated research question: *How to develop an analysis method that integrates the concept of capability-based planning and project portfolio management?* The proposed method provided as a result of this research is expected to help organizations with making decisions regarding investments based on capabilities and multiple selection criteria. The proposed method consists of eight steps that must be performed, could be in parallel. In addition, several techniques are incorporated in the method in order to support the analysis required. This includes combination of multi-criteria decision-making method, enterprise-architecture-based modelling, and mathematical programming model.

The systematic literature review part in Chapter 2 provides the necessary knowledge required to develop the method. The results of the literature review answer the first and the second sub-research questions regarding state of the art of both CBP and PPM concepts, and available analysis techniques for both related concepts. The literature review shows that project portfolio management and capability-based planning are two crucial concepts that could give benefits for the organization when it is done properly. Based on the literature, PPM is also considered as a broad discipline and it consists of many processes with various elements in it. In addition, it is also mentioned in the literature that project selection process is one of the key elements of PPM, which is why this research focuses mainly on project selection aspect of PPM. It is important to decide which elements of PPM will be integrated with the concept of CBP in order to select relevant analysis for the method.

Additionally, several analysis techniques for analyzing projects and capabilities are also described in Chapter 2. With regards to the concept of CBP, the literature shows that while several methods to implement this concept in organizations have been developed, there are still not many available assessment techniques for capabilities. This might be due to the fact that the CBP concept is still considered as a new approach for organizations and thus still in the emerging phase, as opposed to the concept of PPM. Consequently, this might also be the reason why comprehensive research about the integration and connection between CBP and PPM still lacks in the literature.

Furthermore, based on the literature, the Analytical Hierarchy Process (AHP) method is chosen as the techniques for capability assessment and analysis. For the analysis part, EA-based modelling is also chosen as additional techniques to assess projects and to determine project attributes such as impact, cost, risk, and benefit. The motivation behind this is mainly because model-based analysis plays a central role in project implementation, in which it will define the desired future situation when a project is implemented as target architecture. Moreover, a linear programming model that is known as Data Envelopment Analysis (DEA) is also chosen as the main techniques for project selection analysis.

In chapter 3, the proposed method is developed and described in detail. This serves mainly as the answer for the third sub-research question: *How to develop an analysis method that integrates CBP and PPM concept?* The method developed consists of eight main steps, in which several of these might need to be performed more than once depending on the situation. These activities are divided into some analysis that are designed specifically for capability assessment, a combination of projects and capabilities assessment, and also for specific project assessment. It includes strategic capability analysis, capability metrics analysis, project impact analysis, change impact analysis, cost analysis, risk analysis, benefits analysis, and finally project selection analysis. As mentioned earlier, some techniques that are incorporated in the method to support the analysis is also described in detail in Chapter 3.

To provide an overview of how to use the proposed method in a real situation, as well as to answer the last sub-research question (*How to validate the proposed method in practice?*), a case study of an energy power supplier company is provided in Chapter 4. Subsequently, the case study was presented in a small workshop attended by five participants from a company as part of the evaluation. The result of the evaluation shows that overall the proposed method is considered useful for the practitioners, which leads to the willingness to use the proposed method in the future. Detail analysis on the result of the evaluation is provided in Chapter 5 of the thesis. It can also be concluded that the proposed method receives positive feedback from the practitioners.

## 6.2 Contributions

This part discusses the overall contributions of this research. The contributions include contribution to theory and contribution to practice. Both will be explained briefly in section 6.2.1 and 6.2.2, respectively.

### 6.2.1 Contributions to Theory

This section presents the list of contribution to theory. In terms of contribution to theory, the contributions are as follows:

1. While detailed guideline or methods on how to assess capabilities still lack in the literature, this research proposed the use of MCDA methods (AHP) for capability assessment. The AHP method is used to transform qualitative analysis (judgment from decision-makers) to quantitative analysis in order to be used for the project selection analysis.

2. In this research we proposed the integration of capability based planning and project portfolio management. The result of capability assessment is used as one of the main criteria in project selection analysis.
3. Proposed a new way to analyze projects (cost, risk, and benefit) using EA-based modelling based on impact analysis. This includes the adoption of change impact analysis in enterprise architecture to detect possible costs generated in a project.
4. This research introduced the concept of benefit in ArchiMate and its comparison with risk and security concepts.

### 6.2.2 Contributions to Practice

Following a brief description about the contribution in theory, in this section we present the contribution of this research in practice. There are four main contributions that our research contributed to, which include:

1. The proposed method was modelled in ArchiMate language since both the concept of capabilities and projects are available in ArchiMate language. This means that it could also facilitate combining the proposed method with other methods which follow the principles of ArchiMate language.
2. The proposed method can be used by organizations as a guideline for analyzing investments or projects to be selected based on specific concern. It incorporates the common criteria used for project selection with capability assessment result as additional input for project selection.
3. The proposed method could be considered as a new way for an organization to analyze a project proposal using Enterprise Architecture-based modelling. In other words, the proposed method enables the organization to conduct a business case in which it evaluates the cost, risk, and benefit of alternative options and provides justification for the chosen solution.
4. The proposed method can help to ease and enhance the use of analytical methods such as AHP for group decision making in the organization, especially in the area of project portfolio management and capability-based planning.

### 6.3 Research Limitation

There are several limitations of the research which are necessary to be mentioned. Some limitations can be closely linked to the recommendation and future work. The list of research limitations can be found as follows:

- There are other analysis methods available that could be used for project selection based on the selected criteria and constraints, such as customized mathematical programming model. However, due to the limitation of the author and time-constraint, it is not possible to formulate a new mathematical programming model for the proposed method.
- This research uses a trial version of a third-party software for the calculation of DEA model. As mentioned in the previous section, this means that the result of the

calculation depends on the mathematical model developed by the creator of the software. In this case, since the trial version is used, not all models are available. In the model used from the software, it is possible to have more than one projects that are considered efficient. However, this problem could be tackled if we use the 'Super Efficiency Model' that is only available in the full version of the software.

- In the demonstration part (Chapter 4), the proposed method is implemented in a case study. However, some of the input data regarding the case are based on assumptions made due to the limited information provided in the case. Even though it is sufficient to prove the efficacy of the proposed method, using real requirement's information is more recommended since could bring more clarity and provide a better result.

#### 6.4 Future Research

In this section, the list of future works that can be done to improve the research and also to solve the issue in the limitations section is provided. The list of future works is as follows:

- In order to broaden the scope of the research, a combination of both analytical or quantitative methods with existing qualitative methods could be done to assess capabilities or capability performance. By combining these methods, more accurate results of capability assessment and performance level could be obtained.
- In future work, a more in-depth research on how to build a business case based on enterprise architecture could be done. It can also incorporate some other elements in the business case that was not covered in this research such as in-depth financial analysis to calculate NPV and ROI, along with detail execution or implementation plan.
- For further research, more types of analysis can be added into the method to provide a more comprehensive and complete approach in order to support decision-making process in organizations.
- As mentioned in the previous section, this research proposed the integration of capability assessment with project selection process. For further research, integration of capability analysis with other activities in project portfolio management could be evaluated, such as in portfolio optimization, resource allocation, or project portfolio evaluation.
- In this research, capabilities-based planning serves as an input for project portfolio management. It was also argued that the result of project portfolio management, when the project is successfully implemented, could be used as input to assess if capability increment is realized by the project implementation. Thus, research in this area could be done to investigate the relationships between the two concepts in alternating direction.
- One of the feedback received from the evaluation is to make the method easy to use and less 'technical looking', so it could really help customers in selecting projects and allocate investments. This idea could be explored further in the future possibly by developing a software that incorporates the analysis used in the proposed method.

- Another recommendation from the evaluation is to model benefit with the concept of 'Outcome' in ArchiMate. This possibility could be explored more in the future research related to the connection between benefit management and enterprise architecture.

## References

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## Appendix

### Appendix 1: Definition of PPM Constructs

Block	Activity	Description
Knowledge of the organizational context (KOC)	Stakeholders Expectations	Existence of a formal planning process, reflecting internal and external stakeholder's perspectives
	Constraint Capability Uncertainties	It is necessary to have a certain knowledge about the constraints, capabilities, uncertainties information about the organization.
	Organizational Strategy	Have strategic performance measure systems
Main Portfolio Management Process	Decision Criteria (DC)	Identify the Criteria for: individual project evaluation project selection and prioritization
	Resource Allocation (RA)	Identify the resource to be allocated
	Opportunity Identification (OI)	Provide a global vision of the entire portfolio of projects with brief information of the candidate proposals (scope, objective, value, earnings, market etc.)
	Classification (CL)	Consists of the projects classification used to compare similar projects so that the budget can be allocated to projects according to classification. Besides, projects with the same classification are compared and may have concurrent resources that could support the resources management.
	Balancing (BAL)	Balance the criteria (e.g. investment and outcome) to align the project portfolio with the organization's strategy.
	Selection. Prioritization. Optimization and Sequencing (SPOS)	In the research, Selection, prioritization, optimization and sequencing are grouped together. Optimization is to consider resource limitations as a constraint in the analysis of which and how many projects an organization should approve for a given period. Optimization tools are used in allocation resources and prioritization of projects Tools or models could be adopted in these activities
	Approval (APP)	Set the gateway to support formal approval process of projects in the enterprise.
	Formation of Portfolio (FP)	This step is suggested by PMI (Project Management Institute, 2013). It allows multi-project level to conduct the approved portfolio and it provides the planning of projects in the portfolio.
Project Portfolio Management Infrastructure (PPMI)	Evaluation (EV)	The project evaluation is set for reviewing the ongoing projects in the portfolios. The study shows the literature review result that the key performance indicators of projects in this step should include: a) The alignment of the project with the organization's strategic plan; b) Compare the projects to each other and compete for the same resources.
	Project Management Infrastructure (PMO)	Influence of the types of PMO on portfolio management
	Information Technology Infrastructure (IT)	Impact of the use of IT on project success
	Project Management Maturity (OPM)	The OPM selected in the model because the maturity stage of project management in an organization will affect the performance of the strategy implementation.

Figure 50 Definition of PPM Constructs and Elements

## Appendix 2: Summary of MCDA Methods

Table 45 Summary of MCDA Methods, adopted from (Velasquez & Hester, 2013)

Method	Description	Benefit	Limitation	Area of Application
<b>Multi-Attribute Utility Theory (MAUT)</b>	An expected utility theory that can decide the best course of action in a given problem by assigning a utility to every possible consequence and calculating the best possible utility	Takes uncertainty into account; can incorporate preferences.	Needs a lot of input; preferences need to be precise.	Economics, finance, actuarial, water management, energy management, agriculture
<b>Analytic Hierarchy Process (AHP)</b>	A theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales	Easy to use; scalable; hierarchy structure can easily adjust to fit many sized problems; not data intensive.	Problems due to interdependence between criteria and alternatives; can lead to inconsistencies between judgment and ranking criteria; rank reversal.	Performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning.
<b>Case-Based Reasoning (CBR)</b>	A method that retrieves cases similar to a problem from an existing database of cases, and proposes a solution to a decision-making problem based on the most similar cases	Not data intensive; requires little maintenance; can improve over time; can adapt to changes in environment.	Sensitive to inconsistent data; requires many cases.	Businesses, vehicle insurance, medicine, and engineering design.
<b>Data Envelopment</b>	DEA uses a linear programming	Capable of handling multiple inputs	Does not deal with imprecise data; assumes that all	Economics, medicine, utilities, road

<b>Analysis (DEA)</b>	technique to measure the relative efficiencies of alternatives	and outputs; efficiency can be analyzed and quantified.	input and output are exactly known.	safety, agriculture, retail, and business problems.
<b>Fuzzy Set Theory</b>	An extension of classical set theory that “allows solving a lot of problems related to dealing the imprecise and uncertain data”	Allows for imprecise input; takes into account insufficient information.	Difficult to develop; can require numerous simulations before use.	Engineering, economics, environmental, social, medical, and management.
<b>Simple Multi-Attribute Rating Technique (SMART)</b>	One of the simplest forms of MAUT that requires two assumptions, namely “utility independence and preferential independence”	Simple; allows for any type of weight assignment technique; less effort by decision makers.	The procedure may not be convenient considering the framework.	Environmental, construction, transportation and logistics, military, manufacturing and assembly problems.
<b>Goal Programming (GP)</b>	A pragmatic programming method that is able to choose from an infinite number of alternatives	Capable of handling large-scale problems; can produce infinite alternatives.	It’s ability to weight coefficients; typically needs to be used in combination with other MCDM methods to weight coefficients.	Production planning, scheduling, health care, portfolio selection, distribution systems, energy planning, water reservoir management, scheduling, wildlife management.
<b>ELECTRE</b>	An outranking method based on concordance analysis	Takes uncertainty and vagueness into account.	Its process and outcome can be difficult to explain in layman’s terms; outranking causes the strengths and weaknesses of the	Energy, economics, environmental, water management, and

			alternatives to not be directly identified.	transportation problems.
<b>PROMETHEE</b>	An outranking method that is for partial ranking and complete ranking of alternatives	Easy to use; does not require assumption that criteria are proportionate.	Does not provide a clear method by which to assign weights.	Environmental, hydrology, water management, business and finance, chemistry, logistics and transportation, manufacturing and assembly, energy, agriculture.
<b>Simple Additive Weighting (SAW)</b>	A value function is established based on a simple addition of scores that represent the goal achievement under each criterion, multiplied by the particular weights	Ability to compensate among criteria; intuitive to decision makers; calculation is simple does not require complex computer programs.	Estimates revealed do not always reflect the real situation; result obtained may not be logical.	Water management, business, and financial management.
<b>Technique for Order Preferences by Similarity to Ideal Solutions (TOPSIS)</b>	An approach to identify an alternative which is closest to the ideal solution and farthest to the negative ideal solution in a multi-dimensional computing space	Has a simple process; easy to use and program; the number of steps remains the same regardless of the number of attributes.	Its use of Euclidean Distance does not consider the correlation of attributes; difficult to weight and keep consistency of judgment.	Supply chain management and logistics, engineering, manufacturing systems, business and marketing, environmental, human resources, and water resources management.

### Appendix 3: AHP Calculation – Strategic Capability Analysis

Based on the example provided in Chapter 3, the goal of the strategic capability analysis is to determine which capabilities are considered important to address the specified concern. Usually when an organization has a problem or concern, there are multiple assessments related to the concern or the causes of the problem. Thus, using the Analytical Hierarchy Process (AHP) method, the assessment will be seen as the criteria to determine which capabilities are relevant for the specified concern. The first step in the AHP method is to determine the importance of criteria. This could be done in a workshop setting that includes the key decision makers from relevant division in the organization. Moreover, there are many different methods and scaling approach to derive priorities. In this research, we use the original measurement scale for the judgements proposed by Saaty (2008) as the fundamental scale, which reaches from 1 (equal importance) to 9 (extreme importance/9-fold higher importance). The importance of criteria for the sample case provided is presented in Table 46 below.

Table 46 Importance of Criteria calculation

#### AHP Method for selecting the relevant capability based on the concern

##### IMPORTANCE OF CRITERIA

	(1)	(2)	(3)	(4)
Decreasing customer satisfaction (1)	1,000	5,000	6,000	7,000
Lower quality of products (2)	0,200	1,000	2,000	0,500
Insufficient personnel (3)	0,167	0,500	1,000	0,200
Lack of marketing innovation (4)	0,143	2,000	5,000	1,000
sum	1,510	8,500	14,000	8,700

Next, the importance of the criteria must be normalized to determine the priority of each criteria. The normalized matrix of the data is presented in the following table.

Table 47 Normalized matrix of criteria

					Weights
Decreasing customer satisfaction (1)	0,662	0,588	0,429	0,805	<b>0,621</b>
Lower quality of products (2)	0,132	0,118	0,143	0,057	<b>0,113</b>
Insufficient personnel (3)	0,110	0,059	0,071	0,023	<b>0,066</b>
Lack of marketing innovation (4)	0,095	0,235	0,357	0,115	<b>0,201</b>
checksum	0,905	0,765	0,643	0,885	1,000

Criteria priorities or the final weights represent the importance of each specific criteria. Based on the result above, we can see that decreasing customer satisfaction has the highest weight,



which means it is considered as one of the most relevant assessment for the problem. Once the importance of criteria has been determined, the next step is to evaluate the alternative of choices based on the criteria. In this case, the alternatives are the capabilities as depicted in the problem structure. For each criterion, the capabilities are evaluated based on whether the capabilities are related to the assessment or not. In this case, a scale of one to ten (1-10) will be used for evaluation of choices with highest score implies the most significant impact, as shown in the table below.

Table 48 Alternatives Evaluation

EVALUATION OF CHOICES:				
<b>Product Management</b>	3,00	5,00	1,00	1,00
<b>Customer Management</b>	9,00	2,00	7,00	4,00
<b>Marketing Management</b>	1,00	1,00	3,00	7,00
<b>Personnel Management</b>	5,00	1,00	3,00	1,00

It is important to mention that the evaluation of choices could be also presented in separate table for each of the criteria. However, due to simplification of data, the evaluation of choices for all criteria is combined in the table above. This data must also be normalized in order to determine the final weights of the alternatives, or in this case, the capabilities. The normalized matrix of the alternatives evaluation is presented in the table below.

Table 49 Normalized Matrix of Alternatives

COLUMN-NORMALIZED MATRIX:				
Product Management	0,166667	0,555556	0,071429	0,076923
Customer Management	0,5	0,222222	0,5	0,307692
Marketing Management	0,055556	0,111111	0,214286	0,538462
Personnel Management	0,277778	0,111111	0,214286	0,076923
checksum	1,000	1,000	1,000	1,000

Once the criteria and alternative priorities are determined, global alternative priorities can be calculated using aggregation, to gain a ranking of the alternatives based on the evaluation on each criterion. The result of this calculation is presented in the table below.

Table 50 Final AHP Result

Capabilities	SCORES
<b>Product Management</b>	0,186
<b>Customer Management</b>	<b>0,430</b>
<b>Marketing Management</b>	0,169
<b>Personnel Management</b>	0,215
<b>checksum</b>	1,000

Based on the result above, we can determine the ranking of capabilities. These rankings and weights represents the significance level of the capabilities with regards to the assessment of the problem stated in the beginning. Thus, it can be concluded that capability 'Customer Management' is the most relevant capabilities in order to address the problem of decreasing customer base.

## Appendix 4: AHP Calculation – Capability Metrics Analysis

In this part, the calculation of the AHP Method for step 2 and step 3 of the proposed method is provided. The calculation for both of these steps is combined together, since it can be structured as one problem hierarchy in the AHP method. The steps taken for the AHP method is similar to the steps in Strategic Capability Analysis provided in Appendix 2. Basically, we need to determine importance of criteria, perform evaluation of choices based on the criteria, and calculate the final result. The capability metrics defined in step 2 will be treated as criteria, while the possible or proposed projects will be treated as the alternatives or choices. Once the capability metrics has been defined, the first step in the AHP method is to determine the importance of these metrics. The importance of capability metrics and the normalized matrix are presented in Table 51 and Table 52 below, respectively.

Table 51 Importance of Criteria - Capability Metrics

	Response Time	Waiting Time	Retention Rate	Acquisition Cost
Response Time	1,000	5,000	3,000	4,000
Waiting Time	0,200	1,000	0,500	0,500
Retention Rate	0,333	2,000	1,000	2,000
Acquisition Cost	0,250	2,000	0,500	1,000
sum	1,783	10,000	5,000	7,500

Table 52 Normalized Matrix - Capability Metrics

Capability Metrics	Weights				
Response Time	0,561	0,500	0,600	0,533	<b>0,549</b>
Waiting Time	0,112	0,100	0,100	0,067	<b>0,095</b>
Retention Rate	0,187	0,200	0,200	0,267	<b>0,213</b>
Acquisition Cost	0,140	0,200	0,100	0,133	<b>0,143</b>
checksum	1,000	1,000	1,000	1,000	1,000

Based on the normalized matrix, we can see that the weights represent the importance level of each metric. This means that the higher score implies that the metric is considered more relevant to address the problem or concern in the organization. All of these scores will be used for the final calculation to determine the score of the project. Once the importance of criteria has been determined, the next step is to evaluate the possible projects based on the impact of the project to capability metrics. The AHP calculation for this evaluation is presented in table below.

Table 53 Evaluation of Projects

EVALUATION OF CHOICES:

	Response Time	Waiting Time	Retention Rate	Acquisition Cost
Project 1	4,00	1,00	1,00	1,00
Project 2	2,00	2,00	7,00	4,00
Project 3	1,00	3,00	3,00	7,00
sum	7,00	6,00	11,00	12,00

Once the evaluation has been made, the next step is to calculate the normalized value based on the evaluation. The normalized matrix of the project evaluation is presented in the following table.

Table 54 Normalized Matrix of Project Evaluation

COLUMN-NORMALIZED MATRIX:				
<b>Project 1</b>	0,571428571	0,166666667	0,090909091	0,083333333
<b>Project 2</b>	0,285714286	0,333333333	0,636363636	0,333333333
<b>Project 3</b>	0,142857143	0,5	0,272727273	0,583333333
<b>checksum</b>	1,000	1,000	1,000	1,000

Since the weights for capability metrics and project evaluation have been determined, the final priority for the projects can be calculated using aggregation approach in order to rank of the projects based on the capability metrics. The result of this calculation is presented in the table below.

Table 55 Final AHP Calculation

Proposed Projects	AHP Scores:
<b>Project 1</b>	0,361
<b>Project 2</b>	0,372
<b>Project 3</b>	0,268

The result of the calculation above shows the ranking of the proposed projects based on the impact of the project to capability metrics defined in the previous step. These scores as a result of the AHP calculation will be used as input for step 8 of the proposed method, which is the project selection analysis using DEA method.

## Appendix 5: Process Classification Framework for Utility Energy Industry

Table 56 EPS's high-level business capabilities (based on APQC's PCF, 2016)

Category	Name	Description
1.0	Vision and Strategy Development	Establishing a direction and vision for an organization. This involves defining the business concept and long-term vision, as well as developing the business strategy and managing strategic initiatives.
2.0	Products and Services Development and Management	Detailing practices and procedures related to the concept of developing and managing products and services.
3.0	Marketing and Sales Management	Outlining process groups related to understanding markets, customers, and capabilities; developing marketing strategies; executing marketing plans; developing sales strategies; developing and managing marketing plans; and managing sales partners and alliances.
4.0	Physical Products Delivery	Performing supply chain activities include planning supply chain, procuring materials and services, and managing logistics.
5.0	Services Delivery	Offering services to customers. This is the act of providing service delivery as a core business practice and covers identifying strategies for performing service delivery, managing resources, and delivering services to the customer.
6.0	Customer Service Management	Managing customers before and after the delivery of services. This includes developing and planning customer service practices with an eye on steering processes relating to inquiries after sales, feedback, warranties, and recalls.
7.0	Human Capital Development and Management	Delivering processes traditionally defined as human resources. Process groups include those related to developing and maintaining workforce strategy, recruiting employees, developing and counseling employees, managing employee relations, rewarding and retaining employees, redeploying and retiring employees, managing employee information, and managing employee communications.
8.0	Information Technology (IT) Management	Managing process groups relevant to the business of information technology within an organization. This includes manage the business of information technology, develop and manage IT customer relationships, develop and implement security, privacy, and data protection controls, manage

		enterprise information, develop and maintain information technology solutions,, deploy information technology solutions, and deliver and support information technology solutions.
<b>9.0</b>	Financial Resources Management	Overseeing key back-office processes for organizations. This category includes process groups related to planning and management accounting, revenue accounting, general accounting and reporting, fixed-asset project accounting, payroll, accounts payable and expense reimbursements, treasury operations, internal controls, tax management, international funds/consolidation, and global trade services.
<b>10.0</b>	Assets Acquisition, Construction, and Management	Relating to the design, construction, acquisition, and management of both productive and non-productive assets.
<b>11.0</b>	Enterprise Risk, Compliance, Remediation, and Resiliency Management	Ensuring that an organization effectively manages its risk. Process groups are aligned with traditional risk management activities.
<b>12.0</b>	External Relationships Management	Fostering external relationships with stakeholders of the entity, including investors, government and industry, the board of directors, and the public. This is not related to customer management.
<b>13.0</b>	Business Capabilities Development and Management	Performing activities by an organization that are fundamental to the successful operation of the organization, even across functions in a business. Capabilities defined in the PCF include business process management; portfolio, program, and project management; quality management; change management; benchmarking; environmental health and safety management; and knowledge management.
<b>14.0</b>	Utility Assets Operation	Captures these energy utility operations and metering processes. In this process category, utilities operate utility networks (e.g., power transmission and distribution grid, gas distribution network, and water supply network) to deliver utility commodities to customers, operate plants (e.g., generation plants, water and wastewater treatment plants, and pumping and pressurization plants), collect and manage metering data, and manage and operate metering assets.

## Appendix 6: AHP Calculation – Strategic Capability Analysis EPS

Based on the case study provided in Chapter 4, the goal of the strategic capability analysis is to determine which capabilities are considered important to address the problem of low customer satisfaction. Multiple assessments related to this particular concern were made in order to analyze what are the relevant capabilities to solve this problem. The first step in the AHP method is to determine the importance of these assessments. This could be done in a workshop setting that includes the key decision makers from relevant division in the organization. The importance of criteria for the EPS case is presented in Table 57 below.

Table 57 Importance of Criteria calculation (EPS)

AHP Method for selecting the relevant capability based on the concern  
IMPORTANCE OF CRITERIA

	(1)	(2)	(3)	(4)	(5)	(6)
Unresolved complaints (1)	1,000	3,000	2,000	7,000	0,500	5,000
Inefficient switching process (2)	0,333	1,000	0,200	6,000	5,000	2,000
Poor customer service (3)	0,500	5,000	1,000	5,000	6,000	6,000
Inefficient complaint processing (4)	0,143	0,167	0,200	1,000	0,333	7,000
Inefficient billing process (5)	2,000	0,200	0,167	3,000	1,000	3,000
Lack of channel in customer service (6)	0,200	0,500	0,167	0,143	0,333	1,000

Next, the importance of the criteria of the assessments must be normalized to determine the priority weight of each assessment. The normalized matrix of the data is presented in the following table.

Table 58 Normalized matrix of criteria (EPS)

							Weights
<b>Unresolved complaints (1)</b>	0,239	0,304	0,536	0,316	0,038	0,208	<b>0,349</b>
<b>Inefficient switching process (2)</b>	0,080	0,101	0,054	0,271	0,380	0,083	<b>0,126</b>
<b>Poor customer service (3)</b>	0,120	0,507	0,268	0,226	0,456	0,250	<b>0,280</b>
<b>Inefficient complaint processing (4)</b>	0,034	0,017	0,054	0,045	0,025	0,292	<b>0,037</b>
<b>Inefficient billing process (5)</b>	0,479	0,020	0,045	0,135	0,076	0,125	<b>0,170</b>
<b>Lack of channel in customer service (6)</b>	0,048	0,051	0,045	0,006	0,025	0,042	<b>0,037</b>
<b>checksum</b>	0,439	0,912	0,857	0,813	0,873	0,542	1,000

Criteria priorities or the final weights represent the importance of each specific criteria. Based on the result above, we can see that unresolved complaints and poor customer service are in the top highest scores, which means they are considered as relevant assessments for the low customer satisfaction problem. Once the importance of criteria has been determined, the next step is to evaluate the alternative of choices based on the criteria. For each criterion, the capabilities are evaluated based on whether the capabilities are related to the assessment or not. The result of the evaluation of capabilities is depicted in the table below.

Table 59 Alternatives Evaluation (EPS)

EVALUATION OF CHOICES:						
<b>Customer Relation Management</b>	8,00	5,00	8,00	7,00	4,00	6,00
<b>Billing Management</b>	5,00	2,00	1,00	4,00	7,00	1,00
<b>Customer Data Management</b>	1,00	1,00	3,00	7,00	5,00	3,00
<b>Measurement Data Management</b>	5,00	1,00	3,00	1,00	6,00	2,00

It is important to mention that the evaluation of choices could be also presented in separate table for each of the criteria. However, due to simplification of data, the evaluation of choices for all criteria is combined in the table above. This data must also be normalized in order to determine the final weights of the alternatives, or in this case, the capabilities. The normalized matrix of the alternatives evaluation is presented in the table below.

Table 60 Normalized Matrix of Alternatives (EPS)

COLUMN-NORMALIZED MATRIX:						
<b>Customer Relation Management</b>	0,421053	0,555556	0,533333	0,368421	0,181818	0,5
<b>Billing Management</b>	0,263158	0,222222	0,066667	0,210526	0,318182	0,083333
<b>Customer Data Management</b>	0,052632	0,111111	0,2	0,368421	0,227273	0,25
<b>Measurement Data Management</b>	0,263158	0,111111	0,2	0,052632	0,272727	0,166667

Once the criteria and alternative priorities are determined, global alternative priorities can be calculated using aggregation, to gain a ranking of the alternatives based on the evaluation on each criterion. The result of this calculation is presented in the table below.

Table 61 Final AHP Result

Selected Capabilities:	SCORES:
<b>Customer Relation Management</b>	<b>0,430</b>
<b>Billing Management</b>	0,204
<b>Customer Data Management</b>	0,150
<b>Measurement Data Management</b>	0,216

Based on the result above, we can determine the ranking of capabilities. These rankings and weights represents the significance level of the capabilities with regards to the assessment of the problem stated in the beginning. Thus, it can be concluded that capability 'Customer Relation Management' is the most relevant capabilities in order to address the problem of low customer satisfaction in EPS.



## Appendix 7: AHP Calculation – Capability Metrics Analysis EPS

In this part, the calculation of the AHP Method for step 2 and step 3 in the case study of EPS are provided. The calculation for both of these steps is combined together, since it can be structured as one problem hierarchy in the AHP method. The steps taken for the AHP method is similar to the steps in Strategic Capability Analysis provided in Appendix 2. Basically, we need to determine importance of criteria, perform evaluation of choices based on the criteria, and calculate the final result. The capability metrics defined in step 2 will be treated as criteria, while the possible or proposed projects will be treated as the alternatives or choices. Once the capability metrics has been defined, the first step in the AHP method is to determine the importance of these metrics. The importance of capability metrics and the normalized matrix are presented in Table 62 and 63 below, respectively.

Table 62 Importance of Criteria - Capability Metrics (EPS)

### IMPORTANCE OF CRITERIA

	Task Time	Response Time	Data Accuracy	Data Transparency
Task Time	1,000	0,250	0,500	5,000
Response Time	4,000	1,000	5,000	2,000
Data Accuracy	2,000	0,200	1,000	6,000
Data Transparency	0,200	0,500	0,167	1,000

Table 63 Normalized Matrix - Capability Metrics (EPS)

Capability Metrics	Weights				
<b>Task Time</b>	0,139	0,128	0,075	0,357	<b>0,175</b>
<b>Response Time</b>	0,556	0,513	0,750	0,143	<b>0,490</b>
<b>Data Accuracy</b>	0,278	0,103	0,150	0,429	<b>0,240</b>
<b>Data Transparency</b>	0,028	0,256	0,025	0,071	<b>0,095</b>

Based on the normalized matrix, we can see that the weights represent the importance level of each metric. This means that the higher score implies that the metric is considered more relevant to address the problem or concern in the organization. All of these scores will be used for the final calculation to determine the score of the project. Once the importance of criteria has been determined, the next step is to evaluate the possible projects based on the impact of the project to capability metrics. The AHP calculation for this evaluation is presented in table below.

Table 64 Evaluation of Projects (EPS)

Proposed Projects	Task Time	Response Time	Data Accuracy	Data Transparency
Application consolidation project for switching process	4,00	4,00	5,00	1,00
Smart meter integration with billing/ payment	1,00	2,00	6,00	8,00
Online self-service feature for customers	1,00	4,00	3,00	7,00

Once the evaluation has been made, the next step is to calculate the normalized value based on the evaluation. The normalized matrix of the project evaluation is presented in the following table.

Table 65 Normalized Matrix of Project Evaluation (EPS)

Proposed Projects	COLUMN-NORMALIZED MATRIX:			
Application consolidation project for switching process	0,666666667	0,4	0,357142857	0,0625
Smart meter integration with billing/ payment	0,166666667	0,2	0,428571429	0,5
Online self-service feature for customers	0,166666667	0,4	0,214285714	0,4375
<b>checksum</b>	1,000	1,000	1,000	1,000

Since the weights for capability metrics and project evaluation have been determined, the final priority for the projects can be calculated using aggregation approach in order to rank of the projects based on the capability metrics. The result of this calculation is presented in the table below.

Table 66 Final AHP Calculation (EPS)

Proposed Projects	AHP Scores:
Application consolidation project for switching process	0,404
Smart meter integration with billing/ payment	0,278
Online self-service feature for customers	0,318

The result of the calculation above shows the ranking of the proposed projects based on the impact of the project to capability metrics defined in the previous step. These scores as a result of the AHP calculation will be used as input for step 8 of the proposed method, which is the project selection analysis using DEA method.

## Appendix 8: UTAUT Constructs

Table 67 List of constructs for estimating UTAUT (Venkatesh et al., 2003)

Construct	Definition	Items	Root Constructs
<b>Performance Expectancy</b>	The degree to which an individual believes that using the system will help him or her to attain gains in job performance.	U6: I would find the system useful in my job. RA1: Using the system enables me to accomplish tasks more quickly. RA5: Using the system increases my productivity. OE7: If I use the system, I will increase my chances of getting a raise.	Perceived usefulness (TAM/TAM2 and C-TAM-TPB), extrinsic motivation (MM), job-fit (MPCU), relative advantage (IDT), and outcome expectations (SCT)
<b>Effort Expectancy</b>	The degree of ease associated with the use of the system	EOU3: My interaction with the system would be clear and understandable. EOU5: It would be easy for me to become skillful at using the system. EOU6: I would find the system easy to use. EU4: Learning to operate the system is easy for me.	Perceived ease of use (TAM/TAM2), complexity (MPCU), and ease of use (IDT).
<b>Facilitating Conditions</b>	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system	PBC2: I have the resources necessary to use the system. PBC3: I have the knowledge necessary to use the system. PBC5: The system is not compatible with other systems I use. FC3: A specific person (or group) is available for assistance with system difficulties.	Perceived behavioral control (TPB/DTPB, C-TAM-TPB), facilitating conditions (MPCU), and compatibility (IDT)
<b>Attitude towards Using Technology</b>	An individual's overall affective reaction to using a system	A1: Using the system is a bad/good idea. AF1: The system makes work more interesting. AF2: Working with the system is fun.	Attitude toward behavior (TRA, TPB/DTPB, C-TAMTPB), Intrinsic motivation (MM), Affect toward use (MPCU), and Affect (SCT)

<b>Self-efficacy</b>	Judgment of one's ability to use a technology (e.g., computer) to accomplish a particular job or task	I could complete a job or task using the system... SE1: If there was no one around to tell me what to do as I go. SE4: If I could call someone for help if I got stuck. SE6: If I had a lot of time to complete the job for which the software was provided. SE7: If I had just the built-in help facility for assistance.	Self-efficacy (SCT)
<b>Behavioral Intention to Use</b>	A person's perceived likelihood or subjective probability that he or she will engage in a given behavior	BI1: I intend to use the system in the next <n> months. BI2: I predict I would use the system in the next <n> months. BI3: I plan to use the system in the next <n> months.	Attitude Toward Behavior (TRA, TPB/DTPB, C-TAMTPB), Perceived behavioral control (TPB/ DTPB, CTAM-TPB), Intrinsic motivation (MM)

## Appendix 9: Workshop Questionnaire

7/20/2017

Multi-Criteria and Model-Based Analysis for Project Selection Questionnaire

### Background

1. What is your position in the company? \*

\_\_\_\_\_

2. How often do you use EA-based analysis as part of your job? \*

Mark only one oval.

- Always  
 Very often  
 Sometimes  
 Rarely  
 Never

3. How often do you use analytical Multi Criteria Decision Analysis (MCDA) methods as part of your job? \*

Mark only one oval.

- Always  
 Very often  
 Sometimes  
 Rarely  
 Never

### Performance Expectancy

4. I would like to use the proposed method as it is considered helpful \*

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

5. Using the proposed method enables me to accomplish tasks more quickly \*

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

6. Using the proposed method increases my productivity \*

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

[https://docs.google.com/a/student.utwente.nl/forms/d/1q3aLl3zUea5njCpZdNRxfve3-CaN1rWMUk\\_OAIHvtQ/edit](https://docs.google.com/a/student.utwente.nl/forms/d/1q3aLl3zUea5njCpZdNRxfve3-CaN1rWMUk_OAIHvtQ/edit)

2/5

## Effort Expectancy

7. I would find the proposed method easy to use \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

8. My interaction with the proposed method will be clear and understandable \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

9. Learning to use the proposed method is easy for me \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

## Facilitating Conditions

10. I have the resource necessary to use the proposed method \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

11. I have the knowledge necessary to use the proposed method \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

12. The proposed method is compatible with other systems or tools I use for my work \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

## Attitude Towards technology

13. Using the proposed method is a good idea \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

14. Using the proposed method is a good idea \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

15. The proposed method makes my work more interesting \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

16. I look forward to those aspects of my job that require me to use the proposed method \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

## Self-efficacy

17. I would use the proposed method if could get a help from someone if I got stuck \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

18. I would use the proposed method if there is built-in guide for assistance \*

Mark only one oval.

1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

## Behavioral Intention to Use

19. I intend to use the proposed method in the future to help me completing my job \*

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

20. I predict I would use the proposed method in the future to help me completing my job \*

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

21. I plan to use the proposed method in the future for helping me when dealing with the clients \*

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

## Additional Feedback

Please state any additional feedback regarding the proposed approach