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STRATEGIC INVESTMENT SIMULATION BASED ON ENTERPRISE ARCHITECTURE

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This thesis takes the view of Enterprise architecture while focusing on business development in Information Technology project management. It seeks an answer to a key question: “How can a company use enterprise architecture–based simulation in strategic investment planning?” The thesis has been conducted in the information and communication technology department of a Nordic refining and marketing company.

This research is a case study that uses the Design Science research method with a systematic literature review.

As a result of this study, a Microsoft Excel–based artifact, or a tool, for strategic investment planning is created along with the documented process that led to it. Systematic Literature Review identified a possible advancement in Enterprise Architecture by finding two separate lines of literature that, if combined, would lead to an advancement in theory on how to steer enterprise architecture with architectural control points. Furthermore, SLR also identified a lack of articles describing tools to simulate long-term project investment planning.

Existing tool capability seems to already exist in industry, and research on their capabilities was not found.

Keywords: enterprise architecture, strategy, simulation, finance, tool, artifact

Publishing language: English
Tämä diplomityö tutkii yritysarkkitehtuurin näkökulmasta liiketoiminnan kehitystä tietotekniikan projektien kautta. Tämä tutkimus etsii vastausta tutkimuskysymykseen: "Miten yritys voi käyttää kokonaisarkkitehtuurin pohjautuvaa simulointia strategisessa investointien suunnittelussa?" Työ on tehty tieto- ja viestintäteknikan osastolla pohjoismaisessa jaloissa. Tutkimus on tapaustutkimus, jossa käytetään Desing Science Research tutkimusmallia ja systemaattista kirjallisuuskatsautta.

Tutkimuksen tuloksena on syntynyt Microsoft Excel-pohjainen artefakti, strategisten IT-investointien suunnitteluluen. Lisäksi samalla on luotu ja dokumentoitu prosessi, jonka tuloksena työkalu rakentui.

Systemaattinen kirjallisuuskatsaus yritysarkkitehtuurin julkaisuihin paljasti kaksi erillistä tutkimusjatkumoa. Näiden jatkumoiden yhdistäminen mahdollistaisi teorian edistämisen: strategista kokonaisarkkitehtuuria voitaisiin ohjata arkkitehtuurin ohjauspiisteillä.

Systemaattinen kirjallisuuskatsaus tunnisti myös pitkäaikaisten investointien projektien simulointiin liittyvien akateemisten julkaisujen vähäisyyden.

Olemassa olevia työkaluja vastaavan tyyppisillä valmiuksilla näyttäisi olevan olemassa, mutta tutkimuksia niiden kyvykkyyksistä ei löytynyt.

Avainsanat: yritysarkkitehtuuri, simulaatio, strategia, investointi, työkalu, artefakti

Kieli: Englanti
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-Kristjan
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Abbreviations

DSR  Design Science Research

DSS  Decision Support System

EA  Enterprise architecture

ICT  Information and communications technology

IT  Information technology

KPI  Key performance indicator

MS  Microsoft

PM  Project management

PFM  Portfolio Management (system)

SLR  Systematic literature review

VBA  Visual Basic for Applications
1 Introduction

IT systems run or support virtually all business processes in modern companies. The importance of these systems will increase over time as technology develops. Furthermore, new and more complicated systems will take over and connect to the existing ones. In addition, application trends direct corporations to find application solutions to precise problems, in contrast to the colossal systems that solved multiple problems in the past. This practice is further increasing the number of new systems, and their implementation creates challenges. Especially challenging is the selection of which IT systems to invest in, as resources such as money, people and capability are limited, and good investments should be preferred.

There are a huge number of systems and combinations of systems that can be implemented, and therefore there is a need for a method to determine which systems and combinations are good investments. Particularly, this is discussed in IT portfolio management and Enterprise architecture literatures. However, these literatures seem separate, and their views on the matter differ. In essence, enterprise architecture focuses on the holistic mapping of properties that matter (H. A. Proper 2014), and portfolio management concentrates on high-level finance and risk analysis similar to financial management (Reyck et al. 2005). Despite the differences, both are seen as answers to the question "What projects to do?" (H. A. Proper 2014; Reyck et al. 2005). Essentially, this is the same question as “Which systems to invest in?”, as those systems are implemented as projects.

This thesis takes the view of Enterprise architecture while focusing on business development in IT project management. This thesis has been conducted as Design Science Research in the ICT department of a Nordic refining and marketing company. The company in question has multiple IT projects planning, running and in the completed stage. However, there is little holistic information available on large-scale, very long-term projects that are envisioned by project managers and heads of development in their fields. Furthermore, this is as true for project managers as for management. The same also applies to small and short-term projects as well.

Typically, each project is evaluated as a case. However, holistic evaluation is seldom conducted and when done, it is done manually on an old Microsoft Excel work sheet
that has been modified to suit the current need. However, the company has transitioned into rolling forecast planning, in which the old solution is no longer acceptable because the tool is not suitable for regular updating. Furthermore, it lacks the ability to show origins of presented numbers, which is no longer sufficient.

This study answers the research question – "**How can the case company use enterprise architecture–based simulation in strategic investment planning?**” – by creating a model and a tool. This solution combines and refines data from multiple existing sources inside the organization and creates forecasts that aim to satisfy strategic information needs of the company.

Design Science Research is used as the main method for this study. This method uses inductive, deductive and abductive research approaches. Furthermore, the method creates an artifact and a process description that answers the research question.

For data gathering, literature is reviewed to find existing solutions, examples and knowledge related to the problem studied. Furthermore, systematic literature review is also conducted to find similar tools from literature. Within the company, data is collected by interviews, systems are examined in sufficient detail, and corporate materials are also studied. Furthermore, the study includes inspection of a tool that was previously used to fulfill strategic planning needs in the ICT department.
1.1 Research limitations

This study has been conducted as Design Science Research limited to one case. More precisely to company’s ICT department. This limitation is the following from case study methodology, although the study is not a pure case study research. Moreover, as this is a Masters Thesis, its time cost is approximately 6 months consisting of a total of 800 hours of work. In addition, this thesis is business driven in the sense that the resulting working artifact is emphasized.

Furthermore, Information Systems research in general, when implemented in organizations, is a tangled interplay of work systems, infrastructure, people, development, and implementation, which makes it complex (Alan et al. 2004). This means that much of the study is directed by the rules, demands and resources of the organization. This is true for this research study as well as for information and knowledge that are gathered from a company’s documents, interviews with persons within the company, and the tool that was previously used to help strategic management in ICT strategic planning. However, emphasis is on a working tool rather than on information gathering.

The tool is built upon Microsoft Excel, which limits the solution base to Excel capability. Moreover, this researcher did not have significant Excel expertise on PowerPivot or Visual Basic for Applications (VBA) programming experience prior to this study. Nevertheless, that expertise was developed during this study by building the tool.
1.2 Research questions and identification of the problem

Demand has arisen, in the case company, for a tool that would enable the company to better manage and simulate investment planning of IT projects. For example, what projects can be made when limited resources are taken into account for each year? If a project is not implemented now, when will there be resources for it? Furthermore, resource needs for projects tend to change while projects unfold. Sometimes, allocated resources are released and sometimes more are needed; regardless of the case, resources should be working all the time instead of being used as buffers or simply forgotten.

This demand used to be answered by using an old Microsoft Excel worksheet. However, the company has transited into a rolling forecast planning process in which the old solution was no longer acceptable. This is primarily because updating an old Excel worksheet is difficult and time-consuming, but also because the old tool lacks the ability to display breakdowns of numbers and it is generally viewed as inflexible and outdated. In addition, there is a wish to better utilize and take advantage of the modern capabilities of the platforms upon which these tools are built.

This thesis takes Enterprise architecture’s view in order to build a model and a tool to answer the demand in this case, while considering exiting systems and the understanding in the company. The research question for this purpose is formulated as: How can a company use enterprise architecture–based simulation in strategic investment planning?
2 Research methodology

Term methodology is used here to mean the theory of how research should be conducted (Lewis, Thornhill, and Saunders 2009). This includes philosophy of science; ontology, or the nature of reality; epistemology, representing assumptions about the nature of knowledge and what can be known; and axiology, meaning the role of researchers’ values in the study (Lewis, Thornhill, and Saunders 2009). In this chapter, the philosophical assumptions behind this study are briefly summarized. In addition, this research is following the “structure of science” as presented by Saunders in his 2009 book; however, other sources are used to enrich the structure as well.

The overall realm of this research falls under Pragmatism. It argues that the research question determines the epistemology, ontology and axiology. Furthermore, in this view, some philosophies are more appropriate for answering certain questions than others and could therefore bring value to research. Pragmatism also allows the use of multiple methods in a single study (Lewis, Thornhill, and Saunders 2009).

2.1 Ontology

Subjectivist ontology, according to Lewis, Thornhill, and Saunders (2009), denotes that social phenomena are created by actors interacting reciprocally in various situations. In other words, actors’ perceptions of other actors are affecting their own activities, which consequently affects other actors’ perceptions and activities. This creates a system that is in constant motion. The opposite position is assumed in the objectivist ontology view, which states that social actors can act independently of each other and can be isolated in a system. That is to say: a system or a subsystem is the sum of its parts and, as a result, can be studied and controlled independently (Lewis, Thornhill, and Saunders 2009).

This study agrees with subjectivist ontology and consequently tries to study a phenomenon in its context, in contrast to separating it into pieces and studying one part at a time.
2.2 Epistemology

Ideas about the nature of knowledge can be seen as a continuum that starts from a positivistic view on one side. This positivist side states that scientific knowledge is observable only by senses, or is analytical (Frank 2006). Thus it is anchored in objectivistic ontology.

At the other side of the continuum is realism, which consequently means that there can be things that are not measurable by senses, and a reality exists that does not need a mind to create it. Realism is divided in two views: Critical and Direct. Critical Realism accepts that our senses can deceive us. Moreover, Saunders argues that critical realists’ view on the social world is in line with the needs and purpose of business and management research (Lewis, Thornhill, and Saunders 2009).

Critical realisms’ opposing view is direct realism, which argues that a fault in perception means lack of information. This description leads to an idea that reality is sense-making, and what we think is there is affected by our previous interpretations about reality. This leads to a need for a multi-level study, as knowledge is affected by multiple factors and interconnections. Consequently, a single-level study would easily lead to biased ideas about its subject.

In this thesis, the view is more that of a critical realist. Furthermore, this research goes deeper into the separation of things, humans, and different humans as social actors, namely to Interpretivism. The Interpretivistic view takes into account that social reality, for each actor, is created in interaction with other actors and their perceptions. Also, it is considered a good choice for management research. Furthermore, it allows better understanding of the world from a research subject point of view. (Lewis, Thornhill, and Saunders 2009)

2.3 Approach: inductive, deductive and abduction

Saunders (Lewis, Thornhill, and Saunders 2009) uses the term "research approach" to mean an inductive or deductive research approach. However, there are other terms with the same meaning, such as "Scientific method" (Dresch, Lacerda, and Antunes Jr 2015) but in this thesis Saunders’ terminology is followed.
Saunders (Lewis, Thornhill, and Saunders 2009) defines an inductive approach as a "research approach involving the development of a theory as a result of the observation of empirical data" and a deductive approach as a "research approach involving the testing of a theoretical proposition by the employment of a research strategy specifically designed for the purpose of its testing". Briefly, induction is creating broad theory from limited data, and deduction is testing broad theory with limited data.

Saunders (Lewis, Thornhill, and Saunders 2009) summarizes that an inductive approach puts emphasis on:

- the gaining of understanding of the meanings
- humans being attached to events
- a close understanding of the research context
- the collection of qualitative data
- a more flexible structure to permit changes of research emphasis as the research progresses
- a realization that the researcher is part of the research process
- less concern with the need to generalize

In contrast, Saunders (Lewis, Thornhill, and Saunders 2009) summarizes deduction as:

- scientific principles moving from theory to data
- the need to explain causal relationships among variables
- the collection of quantitative data
- the application of controls to ensure the validity of data
- the operationalization of concepts to ensure clarity of definition
- a highly structured approach
- researcher independence of what is being researched
- the necessity to select samples of sufficient size in order to generalize conclusions
Moreover, Saunders (Lewis, Thornhill, and Saunders 2009) states that it is possible to combine these approaches and that it is often beneficial to do so. Grounded theory, even though seen as mostly inductive, is a combination of both inductive and deductive approaches (Lewis, Thornhill & Saunders 2009). Furthermore, Design Science Research also combines both approaches (Dresch, Lacerda, and Antunes Jr 2015).

As Saunders (Lewis, Thornhill, and Saunders 2009) points out, there exists something besides inductive and deductive approaches. One definition for something in between is the "Hypothetical-Deductive Method" that originates from Karl Popper. This is a falsification method in which the best available knowledge is used to generate theory and then test it. Furthermore, it is listed by Dresch et.al. as the third approach (Dresch, Lacerda, and Antunes Jr 2015). However, there is also another similar approach, defined by Haig as abduction (Haig 1995). Abduction is described as the most plausible explanation in the context of auxiliary claims for observed phenomena, when those phenomena do not follow any accepted hypothesis. Furthermore, heuristics are seen as central to this approach, as they are present when a scientist tries to explain some new and surprising phenomenon. (Haig 1995)

Since this research is following the Design Science Research method by Dresch, all three of the approaches are used in different phases of the study. In general, the deductive approach is implemented with general knowledge and research literature in order to produce a company's specific solutions. The research is conducted in cooperation with a company’s people; therefore, abduction is also used, especially in defining the problem and envisioning the solution. Lastly, induction is used to generalize from the knowledge gained from the study. Furthermore, this research follows Dresch’s proposition of Design Science Research (Dresch, Lacerda, and Antunes Jr 2015), which uses all approaches mentioned here.

### 2.4 Research structure summary

The research structure of this thesis is summarized using Saunders’ model of research structure (Lewis, Thornhill, and Saunders 2009). In addition to the methodology from this chapter, methods that are described in Chapter 4 are also included: Choices, Strategy, Time horizons, and Techniques and procedures. The summary is presented
below in Table 1, where green represents the methodological choices used in this study, and yellow represents choices that are embedded in ones that are selected.

**Table 1: Summary of research structure.** Structure is based on Saunders (Lewis, Thornhill, and Saunders 2009) presenting terminology and structural choices of this research. Structural choices followed in this research are highlighted in green and are sometimes followed by embedded choices highlighted in yellow.

<table>
<thead>
<tr>
<th>Ontology</th>
<th>Objectivism (external reality exists)</th>
<th>Subjectivism (social creation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemology</td>
<td>Positivism</td>
<td>Realism</td>
</tr>
<tr>
<td>Approach</td>
<td>Deductive</td>
<td>Inductive</td>
</tr>
<tr>
<td>Choices</td>
<td>Mono methods (qualitative or quantitative)</td>
<td>Mixed methods (qualitative or quantitative)</td>
</tr>
<tr>
<td>Strategy</td>
<td>Action research</td>
<td>Grounded theory</td>
</tr>
<tr>
<td>Time horizons</td>
<td>Cross-Sectional</td>
<td>Longitudinal</td>
</tr>
<tr>
<td>Techniques and procedures</td>
<td>Data collection and analyses</td>
<td>Documents analysis</td>
</tr>
</tbody>
</table>
3 Introduction to the problem area of this thesis

This chapter aims to open up the area of study and provide understanding of the problem area within the limitations of this study. Thus, scientific literature, causes of the problem and its context, and other information relevant to the research topic are included. In addition, existing artifacts and their functionalities are also considered. Lastly, Systematic Literature Review (SLR) is used to identify research relevant to the research question.

3.1 Enterprise Architecture

The field of Enterprise Architecture (EA) has developed from computer architecture to information systems architecture and eventually to enterprise architecture. As the importance of information systems in business grew, IT and business became more interlinked, and the need for co-design between business and IT emerged. Co-design means that IT design should no longer take business design as a given and instead both should be aligned with each other. In essence, EA has developed from a mere mapping tool into a transformation capability enabler and therefore has become increasingly relevant as firms’ capabilities to adapt in constantly changing environments have become even more critical (H. Proper and Langhorst 2014).

Proper defines Enterprise Architecture as "those properties of an artifact that are necessary and sufficient to meet its essential requirements" (H. Proper and Langhorst 2014). These requirements in essence depend on individual stakeholders’ purposes, goals and concerns. Moreover, these requirements will change over time. (H. A. Proper 2014)

Furthermore, Proper (H. A. Proper 2014) sees EA as being about sense-making. First, EA is about making sense of the past and future of an enterprise. Second, EA provides clear motivations/rationalizations of essential requirements and constraints that are present. This sense-making would enable management to make informed decisions about changes in the enterprise. (H. A. Proper 2014)

The benefits of EA utilizations to the company include improved decision making, evolutionary EA development and governance, improved risk management, and
improved IT investment management (Niemi 2008). Furthermore, EA’s capability to provide evidence for decision making is supported by Ross (Ross 2006), who, in his paper, provided multiple evidences from separate authors. In essence, his paper argues that in the sample group companies with high IT capability outperformed companies with low IT capability, competitive advantage in relation to IT management competence and modular IT infrastructure was sustained, value of information storage was demonstrated, and specifically IT management contributed to competitive advantage, while technical IT skills and infrastructure did not.

EA is seen as a way to answer the question posed by Piccoli (Piccoli and Ives 2005): "What are the principal challenges to gathering and processing the information necessary to carry out many of the value judgments necessary to estimate the strength of the barriers to erosion?" Therefore, there is a need for an increase in evidence-based management and it appears that EA could provide some of this evidence. With EA, current problems can be more sharply analyzed, plans can be communicated more explicitly, cost and benefits of different options can be mapped, and progress can be monitored. Or, in other words, EA enables utilization of the best available evidence. (H. Proper and Langhorst 2014)

3.2 Design running to motion

According to Proper (H. A. Proper 2014), enterprises are constantly changing and that change can be divided into planned and non-planned changes. Furthermore, he generalized different flavors of change, such as business innovation and technology change as “enterprise in motion” (Figure 1). Furthermore, this continuous motion is identified as one of the enterprise’s primary business processes in addition to its normal operations or “running system” as defined by Proper (H. A. Proper 2014).

This leads to the idea of two aspect systems of the enterprise, defined as the running aspect and the motioning aspect. The motioning aspect is about actions changing the enterprise or, in other words, system that develops the enterprise. Furthermore, the motioning aspect is considered to motion itself, that is to change itself, as well as motioning the running aspect of the system. The running aspect of the system is the
regular operational activity of the enterprise – that is, producing the product or service that the company aims to provide. (H. A. Proper 2014)

Enterprises are in constant motion and this motion needs to be directed, or steered, in order for it to be aligned with the purpose and strategy of the enterprise. Consequently, the two aspect systems are divided into four systems: a running producing system that considers producing products; systems that steer the aforementioned system overseeing the production process and confirming that it is followed; a motioning producing system that makes changes to production.; and finally, a system that steers the motioning system – in other words, a process that plans the change. In addition, these aspect systems are separate; however, systems and people who run them can work in multiple aspects or move from one aspect to another. (H. A. Proper 2014)

Figure 1: Enterprise in motion (H. A. Proper 2014)
3.3 Project Portfolio management

A portfolio is a grouping of investments that are held by an entity, and portfolio management is the management of those investments as a whole. IT management has adopted the concept of portfolio management from the field of financial management and has applied it to projects, in order to increase the success of projects. Moreover, the approach is working in companies where it has been adapted. (Jeffery and Leliveld 2004)

While project management (PM) is mainly concerned about completing projects correctly, project portfolio management (PPM) is primarily concerned about completing the correct projects. PPM appraises the entire portfolio of projects that the company has and aims to prioritize worthy projects. This means adding projects, or removing ones that are not seen as beneficial (Reyck et al. 2005). Both PM and PPM evaluate organizations’ risks in projects, value of project benefits to organization, and strategic alignment to organizations’ goals (Jeffery and Leliveld 2004).

From interviews with managers, Reyck (Reyck et al. 2005) compiled a classification scheme for the adoption level of PPM, which also draws a picture of what PPM takes into account. Consequently, the financial roots of PPM are clearly visible, as most countable large scale measures are taken into account. These include costs, risks, constrains of resources, diversification and optimization.

However, PMM accounts little for interdependencies in comparison to EA. For example, Reyck (Reyck et al. 2005) lists sequential dependencies, overlapping outcomes, competition for resources, and change bottlenecks. All of the aforementioned are high-level black box estimates and are distant from EA’s white box thinking, which in contrast can take the form of deep simulation of a significant part of the enterprise, such as in IT cost estimation by Narman (Narman et al. 2009). Moreover, PPM begins when projects started to omit the planning phase.
3.4 Rolling forecast

Traditional annual budgeting is conducted as a fixed cost estimation to a certain period of time. Furthermore, it is done in a certain time of the year and then it is frozen. This approach results in shortcomings because data used for cost planning is past-focused, at least from the moment it is put on paper. For example, a budget is not updated when new data become available, or risks or opportunities occur. Annual budgeting also does not encourage opportunity seeking but instead encourages managers to keep costs under the planned amounts, not above, as this might lead to a smaller budget in the future. (De Leon, Rafferty, and Herschel 2012)

A rolling forecast, in contrast, is future-oriented. It removes the fixed budget and static timeline and replaces those with a budget that is constantly updated based on future estimates and a timeline that is always forecasting the same time into the future. In essence, this involves adding a new month to a forecast when a month passes. As a result, the focus is shifted to the future and annual budgeting is turned into a continuous process. In addition, this enables better utilization of data in decision making, as forecasts are constantly updated based on new data. Consequently, as data can be better utilized and more informed decisions can be made, the demand for business intelligence is increased. That is, data and data quality are increased along with the demand for new tools that provide data in usable form, such as models, simulations, business intelligence and data integrations. (De Leon, Rafferty, and Herschel 2012)

Furthermore, better decision fundaments in the form of business drivers are needed to utilize rolling forecast capabilities. This means better focus on things that affect business and less focus on things that do not affect business or that cannot be influenced. In addition, these effects need to be measured to know their real effect and to recognize them in the first place. As a summary, a rolling forecast requires the utilization of business drivers and, as a result, business intelligence tools are needed as well. (De Leon, Rafferty, and Herschel 2012)
3.5 Informed decision

Making informed decisions means basing decisions on available information. In strategic decisions, information is often ‘soft’ or as experienced by other people. The amount of this information can easily be overwhelming and therefore a filter is needed. (Dare 1979)

An informed decision is seen in this thesis as having sufficient, relevant information related to the decision and context before making the decision. ‘Relevant information’ is information that affects the outcome, and ‘sufficient’ means available with reasonable effort. In essence, uncertainty is decreased by the use of better data, simultaneously increasing decision makers’ understanding of the situation.

3.6 Risk/uncertainty

Risk and uncertainty are much used in the financial literature, but there appears to be different perspectives. In this thesis, the perspective of Frank Knight is used: that is, when the distribution of an event happening is known, it is called risk. Similarly, when the distribution of an event happening is unknown, it is called uncertainty. (Holton 2004)

However, in the financial world, few decisions contain only risk, and uncertainty is almost always present as long as there are things that are unknown, not perceived, ignored or misunderstood. (Holton 2004)

3.7 Systematic literature review

In order to assess the research question field, SLR was performed to find research relevant to the research question and to form a body of research relevant to the research question. SLR as a method is described in Chapter 4.3. Furthermore, as this is a single research and master’s thesis, SLR was conducted concentrating on the most important components of SLR as suggested by Kitchenham (Kitchenham 2004).

A general literature search provided no ready-made SLR of the topic, and the SLR was conducted with the following steps:
1. Systematic literature review was performed with a search string in different databases. The search string was "enterprise architecture" AND strategic AND long-term AND project AND simulation AND tool.

2. All Results were filtered based on title. An exception was Google Scholar, since the search provided 2,620 results and therefore only the first 50 results were taken into consideration.

3. Results were filtered using abstracts.

4. Abstract results were divided into ones that contain a relevant tool and otherwise relevant articles.

5. Tool articles were revived individually.

Results are summarized in Table 2: Literature review results, below.

**Table 2: Literature review results**

<table>
<thead>
<tr>
<th>Source</th>
<th>Found</th>
<th>Title</th>
<th>Abstract</th>
<th>Tool</th>
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</tr>
</tbody>
</table>

Articles found:

1. Tool Support for Enterprise Architecture Management - Strengths and Weaknesses (Ernst et al. 2006)

In essence, SLR returned four articles that could be highly relevant to this research. Additionally, eight possibly relevant articles were identified. However, based on a review of these four articles, it appears that this literature search did not provide any ready-made tools or examples for the tool. However, Dreyfus’ article (Dreyfus and Iyer 2008) provides one solution to the problem described by Proper in “Steering of enterprise in motion” (H. A. Proper 2014).

3.7.1 Review of tool articles
Ernst’s article, “Tool Support for Enterprise Architecture Management - Strengths and Weaknesses”, evaluates EA management support tools from 2005. The article lacks a description of a tool but provides information on the weakness of tools used in 2005. (Ernst et al. 2006)

Ernst uses the EA management definition from Langenberg and Wegmann: “EA management is a continuous and iterative process controlling and improving the existing and planned IT support for an organization. The process not only considers the information technology (IT) of the enterprise, but also business processes, business goals, strategies, etc. are considered in order to build a holistic and integrated view on the enterprise” (Ernst et al. 2006; Langenberg and Wegmann 2004). The definition is essentially relying on Enterprise Architecture defined as “Alignment of business and IT” (Langenberg and Wegmann 2004). Furthermore, Landenberg’s article describes the EA situation as a young discipline. Langenberg concludes that EA publications before 1996 are rare, and in 2005 EA is an immature discipline; more basic research and more publications from companies are needed. (Langenberg and Wegmann 2004)

In addition, Ernst’s article points out that EA management is extensive and complex, and it considers multiple roles. EA management should be supported with tools that aid in its various areas. (Ernst et al. 2006)
The main conclusions of the first part of Ernst’s study are that meta models of tools differ vastly. Some tools contain hundreds of entities with associations and some are delivered with only a few entities, resulting in systems either too complex or not capable. This issue is tackled with tool implementation projects that, with the help of external consultants, bend the tool to fit the company’s needs. Ernst suggests a solution to this problem-adhering approach stemming from “information model patterns” into an enterprise information model. In essence, the solution is not to choose individual pieces to fit the enterprise but rather bigger patterns. In addition, those patterns are documented and there are also descriptions of what using them does to the information model in a company. This is similar to a library of solutions. (Ernst et al. 2006)

The first part of Ernst’s research also points out that collaboration support, working with multiple stakeholders on the same data, is well supported among surviving tools. Areas to develop are identified as visualization support and support to exchange data with other systems, as no standards existed in 2005.

The second part of Ernst’s survey concludes that project and portfolio management, and synchronizations management, are supported in only a few tools. The reason for this is that both require concepts of projects and time, for example project deliverables.

Lastly, Ernst points out that not all tools were supported by descriptions and/or manuals and often teams themselves had to discover the logic of how to use the tool.

An interesting factor in this article is that resources such as money or people are not mentioned. Furthermore, this evaluation does not mention timeframes.

The second result of the SLR was Dreyfus’ article, “Managing Architecture under Emergence: A Conceptual Model and Simulation”. This article shows that enterprises can affect their architectural fitness by managing and monitoring architectural control points. Furthermore, this result was also validated through simulation in a finance company.

Architecture is defined as a social system and pattern of connections, exchange of information, ideas and data, between systems such as hardware, technology, management, and others alike. This also includes people, as they are part of the architecture. Furthermore, real architecture is usually emergent. In other words,
implemented architecture is typically not a designed one, and once it is perfectly mapped it is likely to have changed already. Furthermore, affecting one part of it is likely to affect many other parts. (Dreyfus and Iyer 2008)

Architectural control points are nodes which have the most effect on the entire architecture. However, these points can change while the architecture evolves. These control points are important because affecting the points provides the most effect on the architecture. Architecture is also a description of interdependency, which relates to complexity, which in turn relates to the cost of managing and designing it. Even in simple systems, the costs can be overwhelming compared to the benefits. Furthermore, Dreyfus points out that if an architecture is ‘let loose’ and is not controlled, it tends to vary from the strategy and less effectively supports the company’s goals. (Dreyfus and Iyer 2008)

In addition, Dreyfus concludes that although the initial conditions are important, the greatest impact arises from controlling the evolution of the architecture. Therefore, focus should not be only on designing the system but also on affecting its evolution. (Dreyfus and Iyer 2008)

Thirdly, the article “Magic Quadrant for Business Process Analysis Tools” provides examples of modelling tools, such as Microsoft Vision. The article also defines Business Process Management Suite as “an integrated collection of software technologies that enables process transparency, and, thus, better management of the business process, as well as work in the process”. These tools have some integrations and are designed for specialist use. (Blechar and Sinur 2007)

These systems seem to still remain in the area of mapping and produce the image of the situation and integrate a different tool, however they do not seem to provide logic on how they should be used. They are likely to result in extensive control on some aspects of the system with some good architectural maps of systems, but they do not provide any guide for what would be the most important parts of the system, resulting in the idea that all parts are equally important.

The solution described is to simulate ‘as is’ and ‘to be’ situations. It is essentially decision supports system, simulating key performance indicators. Furthermore, the solution assumes a designer and little data integration. (Swets and Drake 2001)

3.7.2 Summary of literature review and result
Overall only two of the four found articles provide a significant contribution to the topic. Furthermore, no tool example was found from the sources used.

To summarize, the first article points out that EA is extremely complex and multiple tools exist to ease management of it. At the time of this study (2006) there was a lack of project and portfolio capacities of these tools. In addition, the article points out that the nature of these tools is that they are often used as a base and then customized to an organization’s needs. (Ernst et al. 2006)

In the second article, Dreyfus points out that although EA is complex it should be controlled, however it should not be controlled too extensively, as that would not be economical. Dreyfus proposes finding architectural control points that affect the most components of the entire architecture and exercise control on only those points.

Dreyfus’s article is in line with H. A. Proper’s idea, described in Chapter 3.2, of a motioning system. Combining these two ideas would offer an idea of how a motioning system connects to other pieces in Picture 1. A combined solution would suggest that connections are made through Dreyfus’ architectural control points. This could be a good research topic.

Interestingly, these two articles seem to be separate. For example, Dreyfus (Dreyfus and Iyer 2008) is not mentioned in H. A. Proper’s article (H. A. Proper 2014). Furthermore, the only common source was “Zachman, J.A., A framework for information systems architecture, in IBM Systems Journal. 26(3) 1987”. In Dreyfus’ article, the Zachman article source number was 31, and in H. A. Proper’s article, it was 67. Proper had 67 sources and Dreyfus had 55. Comparison was done using Excel fussy look up add-in (“Fuzzy Lookup Add-In for Excel” 2015).
4 Methods

The term ‘method’ is used here to mean ways to obtain information. In other words, "techniques and procedures to obtain and analyze data", as Saunders describes it (Lewis, Thornhill, and Saunders 2009). Methods are, for example: questionnaires, interviews, and techniques, including both quantitative and qualitative analysis. Moreover, different methods can be used in combination with others in the same research project (Lewis, Thornhill, and Saunders 2009).

In this research, Design-Based Research is used as a primary method following Dresch’s guide (Dresch, Lacerda, and Antunes Jr 2015). In addition, the main method is supported by case study and grounded theory, making this a multi-method study according to Saunders’ structure (Lewis, Thornhill, and Saunders 2009). Furthermore, this research is qualitative.

4.1 Qualitative research

Qualitative research is anchored in subjectivist ontology. In other words, reality is socially constructed by individuals in interaction with their realities. Reality is not a set, single, agreed or measurable phenomenon. Furthermore, a qualitative research process is seen primarily as inductive. (Merriam 2002) In contrast, quantitative scientific knowledge is observable by senses and is numerical or has been quantified. Moreover, quantitative research is anchored in objectivistic ontology with quantitative research. (Lewis, Thornhill, and Saunders 2009)

There are multiple constructions and interpretations or realities, which are entangled and change over time. Qualitative research is interested in what those constructions are in their context, and it attempts to describe them. This results in the descriptive nature of qualitative research and a typically richly descriptive end product that does not rely excessively on data. Furthermore, that end product also recognizes that readers will bring their own background, understanding and context into meaning creation. Consequently, value is created when the reader combines all of this into knowledge. (Merriam 2002)
Qualitative research is characterized by taking the participants’ perspective, and that is because the understanding cannot be created without involving people who create the phenomena and meanings that are studied. Another characteristic of qualitative research is that a researcher is recognized as the primary instrument for data collection and data analysis. Since a researcher is human, he or she is good in creating understanding out of this type of data. Moreover, a human is also able to understand language, culture, validity and unusual data. However, this presents drawbacks in the form of biases that need to be identified and monitored. (Merriam 2002)

According to Merriam (Merriam 2002), the primary goal of qualitative research is to understand a phenomenon under study in its context; it is not to try to predict the future or test the theory, as the positivistic approach does and requires (Frank 2006). "Qualitative research builds toward theory from observations and intuitive understanding gleaned from being in the field." (Merriam 2002).

### 4.2 Validity and reliability

The credibility of research depends on validity and reliability. Validity is concerned with measures being actually about what they claim to be and that they have a causal relationship. That is, if a measure is used, it is measuring what it purports to be measuring. Likewise, reliability accounts for findings being consistent. In other words, if measurements are taken again, they will produce the same results and can be therefore replicated. Furthermore, this concept is illustrated in Figure 2, below. (Lewis, Thornhill, and Saunders 2009)

![Validity and Reliability](https://example.com/image.png)

**Figure 2: Validity and Reliability.** Reliability is hitting the same spot but missing the mark. In this case, a mere adjustment can fix the problem. However, if the problem is validity, a mere adjustment may not be sufficient.
4.3 The method of systematically reviewing the literature

A literature review is conducted in order to find and summarize all relevant existing information related to the topic of study. Moreover, an explicit systematic approach makes a study more repeatable, and multiple authors encourage conducting a review systematically. For example, Kitchenham (Kitchenham 2004) states that if a literature review in a study is not "thorough and fair, it is of little scientific value". Khan (Khan et al. 2003) similarly states that reviews should always be done in a systematic manner. According to Khan (Khan et al. 2003), the word ‘systematic’ connected to a review means that the review is "based on a clearly formulated question, identifies relevant studies, appraises their quality and summarizes evidence by use of an explicit methodology".

The SLR in this study was conducted following Kitchenham’s (Kitchenham 2004) guide. Systematic Literature Review is defined as "a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest." (Kitchenham 2004)

One distinct feature of an SLR in comparison with a conventional literature review is that an SLR is conducted with a predefined search strategy in such a manner that its assessment is possible. Specifically, every effort is made to document how a review was conducted and which criteria were used in rejecting or reporting studies that were found. (Kitchenham 2004)

The sequence of SLR in three phases according to Kitchenham (Kitchenham 2004) is:

- Performing an SLR starts with a planning phase. First, determine if an SLR is needed. In particular, does a review that fulfills the needs for this study already exist? After identification of a need for a systematic review, a review protocol is developed.
- The processing phase starts with the identification of research, followed by primary study selection, quality assessment of those studies, data extraction and monitoring, followed by data synthesis.
- Lastly, the review is reported.
Even though this entire process looks sequential, in practice it involves iterations. For example, an SLR protocol may be refined during the process, when more information is available. (Kitchenham 2004)

An SLR requires more effort that a traditional review. Furthermore, Kitchenham’s guidelines are designed for use in a large research study or in a single research project (e.g. that of a PhD student). In a single research project, Kitchenham suggests concentrating resources on the most important steps. (Kitchenham 2004)

### 4.4 Case study

A case study is a research strategy or method that studies a phenomenon in its real-life context using multiple sources of evidence (Lewis, Thornhill, and Saunders 2009). Furthermore, a case study uses other methods for data collection, such as surveys and experiments, and because of that it is sometimes seen more as a process rather than a method (Merriam 1998). Overall, in Merriam's (Merriam 1998) words: "The case study focuses on holistic description and explanation". Moreover, Saunders (Lewis, Thornhill, and Saunders 2009) points out that, in a case study, boundaries between a phenomenon and the context in which it is being studied are blurred, which highlights the importance of the context of study. In contrast, experimental strategy is a strategy in which the context is highly controlled (Lewis, Thornhill, and Saunders 2009)

In essence, a case study involves delimiting the object of study. Phenomena must be intrinsically bounded or there is no case study. There must be a limit to the number of people who could be interviewed or a limit to the number of phenomena to be observed. For example, schools in Finland could constitute a case study, but school policies or relationships among schools would not be typically considered a case study. In case study, there are always a finite number of observations, interviews and amount of time to be used. (Merriam 1998)

Since case study is bound to a case and it aims to generate a rich understanding of studied phenomena, multiple data collection methods are typically used. Furthermore, Saunders recommends the use of triangulation. Triangulation is the use of multiple data collection techniques within one study to verify that data is revealing what it appears to be revealing. (Lewis, Thornhill, and Saunders 2009)
According to Merriam (Merriam 1998), a case study is qualitative: it focuses on written, non-numerical reporting. Furthermore, case studies are characterized by being particularistic, descriptive and heuristic. Particularistic refers to focusing on a particular situation, an event, a program or a phenomenon. This makes it a particularly good design for practical problems. Descriptive means a complete and literal description of an incident or an entity being investigated. Heuristic is the fact that readers’ previous knowledge affects the unfolding of the new knowledge. (Merriam 1998)

Overall, a case study is a good strategy for gaining a rich understanding of a context of research and a process that is acted out. Moreover, the strategy has a good ability to generate answers to ‘why’, ‘what’ and ‘how’ questions. (Lewis, Thornhill, and Saunders 2009) Especially when variables are impossible to identify beforehand and there is little control over events, a case study is seen as a good method in this type of complex system. Furthermore, it emphasizes a process and the uniqueness of a subject of the study that could be easily missed in statistical observations. (Merriam 1998)

On the downside, a case study has biases, it is limited to a specific case, and it can only offer grounds on which to build theories but not for making generalizations. Moreover, biases from a researcher can have extreme effects. (Merriam 1998)

4.5 Grounded method

Grounded theory is described as being good at predicting and explaining behavior while emphasizing theory building and development. Moreover, the method is well suited for a wide range of business phenomena, since business and management are primarily about the behavior of people. Also, grounded theory is a combination of both inductive and deductive research approaches, even though it is primarily seen as an inductive research approach. (Lewis, Thornhill, and Saunders 2009)

A grounded theory approach begins with data collection without an initial theoretical framework. Theory rises from the data gathered from observations. In this way, data leads to prediction generation. Predictions are then tested in addition to data collection, which either confirms or alters the predictions. However, this does not mean that
existing theory should be ignored or read after data collection, rather it is seen as theory building that is grounded to the continuous collection of data, or, in short, a theory arises from constant interaction between the data and the development of the theory. (Lewis, Thornhill, and Saunders 2009) Furthermore, this data is coming from participants who have experienced the process that is being studied. This is also why grounded theory is seen as being qualitative (Creswell 2002).

Creswell states that there are mainly two different views on grounded theory (Creswell 2002). The first, Strauss's view, is highly structural and well rooted in positivistic ideology. The second is found from constructivist writing, and it encompasses many more flexible guidelines taking into account social constructs, researchers’ views, hidden networks, power hierarchies, and so on. (Creswell 2002)

In Strauss’s model, Creswell provides lists of procedures for conducting the grounded theory research. First, the researcher needs to determine if the grounded theory is appropriate for studying the research problem. Strauss’s grounded theory is appropriate when there is no theory available to explain a process, or there is, but it is either not tested or not designed for this particular situation. In addition, grounded theory is particularly suitable for addressing how people are experiencing phenomena. (Creswell 2002)

Second, the procedure is that of asking questions of participants that will focus on how individuals experience the process. After initial exploration, a researcher returns to ask more detailed questions for axial coding. These questions are typically asked in interviews, although other forms of data can also be collected. The aim is to collect enough data to fully saturate the model. (Creswell 2002)

The analysis of the data is conducted in stages: Open coding, axial coding, and selective coding. Analysis using conditional matrix may be performed in the final stage, although it is rarely used. Open coding refers to a researcher forming categories of information from data and discovering properties among these categories. This process may possibly be repeated among subcategories. (Creswell 2002)

In axial coding, data is arranged in new ways. This is shown using a visual model in which a central phenomenon, categories of connections that affect the phenomenon and their effects on outcome, interactions that result from the central phenomenon, and
the context and conditions that affect the phenomenon are all identified. (Creswell 2002)

In selective coding, a hypothesis or a storyline is written to connect categories. If a conditional matrix is developed, it portrays social, historical, and economic influences central to the phenomenon. (Creswell 2002)

The result of this process is a theory that has been performed by a researcher who has been close to a specific problem or people. Theory has emerged with "memo-ing", meaning a researcher records ideas about the theory during the coding procedures. (Creswell 2002)

The grounded theory method seems to be used mainly with qualitative data, especially interviews. In its purest form, it appears to be heavy on work (Sarker, Lau, and Sahay 2000) and very comprehensive in qualitative research (Haig 1995). However, as Creswell points out, there are variations in extensiveness and more flexible methods for conducting grounded theory–based research (Creswell 2002).

Haig (Haig 1995) sees a grounded theory with abduction and not as much of an inductive process as it is usually said to involve. Moreover, he also abandons the idea that a researcher is somehow ‘tabula rasa’, a blank slate, in the beginning. Instead, he points out that the heuristics of the researcher will play a significant role in grounded theory.

4.6 Research interview

An interview is a goal-oriented dialogue between or among two or more people, which aims to gather relevant knowledge or data. Interviews can be categorized as structured, semi-structured or unstructured. Structured interviews are highly formalized and contain specific questions that are answered in a standardized manner, often even with standardized answer options. This is much in line with quantitative research. (Lewis, Thornhill, and Saunders 2009)

In contrast, semi-structured interviews and unstructured interviews are not standardized. Sometimes they are referred to as qualitative interviews and they are well equipped for exploratory research. The agenda of semi-structured interviews
contains a rough list of themes and questions to be covered. Furthermore, topics and questions can be varied depending on a conversation and a researcher’s decisions. Unstructured interviews are informal and in essence allow participants to take control of the interview. In addition, these types of interviews encompass a belief that they reflect the reality at the time of an interview. (Lewis, Thornhill, and Saunders 2009)

4.7 Design Science Research
The Design Science Research (DSR) method is both the created artifact and the process that generated it. The resulting IT artifacts can be constructs, methods, models and instantiations. Artifacts are built to solve a problem or provide utility, and therefore artifacts are evaluated against those goals. In essence, a solution to a problem is the artifact that demonstrates the feasibility of the process that led to it and the solution. In other words, "proof by demonstration" (Nunamaker Jr and Chen 1990): a working solution provides evidence of a solution even if there is not yet a precise understanding of why the solution works. Hevner provides further clarifications: "Knowledge and understanding of a design problem and its solution are acquired in the building and application of an artifact". In addition, the essential questions, according to Hevner, for Design Science Research are, "What utility does the new artifact provide?" and "What demonstrates that utility?" (Alan et al. 2004)

In scientific literature there is no obvious consensus about the boundaries between case study, action research and DSR (Dresch, Lacerda, and Antunes Jr 2015). For example, Järvinen suggests that action research and DRS are similar (Järvinen 2007), and Sein (Sein et al. 2011) even proposes integration. However, Iivari and Venable (Iivari and Venable 2009) disagree and see them as “decisively different” but still compatible. There are also examples of this compatibility from case study and DSR (Dresch, Lacerda, and Antunes Jr 2015).

In this research, for clarity it has been decided to follow Dresch et.al.’s (Dresch, Lacerda, and Antunes Jr 2015) comparison to determine which method would be suitable for this research. Furthermore, the selection of only one method is emphasized in order to reduce complexity.
According to Dresch et.al. (Dresch, Lacerda, and Antunes Jr 2015), the most important difference among these methods is in the objectives. The objective of a case study is to help understand a complex social phenomenon. An action research method attempts to solve or explain a system by generating practical and theoretical knowledge. A design science research method aims to develop artifacts that provide satisfactory solutions to practical problems. In this case, since artifact and a satisfactory solution is critical due to the business link, DSR therefore seems the best choice.

Furthermore, Dresch et.al. (Dresch, Lacerda, and Antunes Jr 2015) provide a comparison Table 3, which further promotes DRS for this research. The type of this research knowledge is definitively focused on how things should be instead of describing how things are, although that is part of solving the problem as well. The researcher’s role is active, which would seem to exclude a case study. Furthermore, the evaluation of results relies heavily on measuring the artifact instead of comparisons with theory. All these concerns further confirm DRS as an appropriate choice for this research. DSR is also a safe choice, as DSR origins are in information systems research.
Table 3: Comparison table (Dresch, Lacerda, and Antunes Jr 2015). This table compares Design Science Research, case study and action research, using various characteristics

<table>
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<th>Case study</th>
<th>Action research</th>
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<td><strong>Objectives</strong></td>
<td>Develop artifacts that</td>
<td>Assist in</td>
<td>Solve or explain</td>
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<td></td>
<td>enable satisfactory solutions to</td>
<td>the understanding</td>
<td>problems of a given</td>
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<td></td>
<td>practical problems</td>
<td>of complex social</td>
<td>system by generating</td>
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<td></td>
<td>Design and recommend</td>
<td>phenomena</td>
<td>practical and</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>theoretical knowledge</td>
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<tr>
<td><strong>Main activities</strong></td>
<td>Define the problem</td>
<td>Define conceptual</td>
<td>Plan actions</td>
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<tr>
<td></td>
<td>Suggest</td>
<td>structure</td>
<td>Collect data</td>
</tr>
<tr>
<td></td>
<td>Develop</td>
<td>Plan the case(s)</td>
<td>Analyze data and plan</td>
</tr>
<tr>
<td></td>
<td>Evaluate</td>
<td>Conduct pilot</td>
<td>actions</td>
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<tr>
<td></td>
<td>Conclude</td>
<td>Collect data</td>
<td>Implement actions</td>
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<tr>
<td></td>
<td></td>
<td>Analyze data</td>
<td>Evaluate results</td>
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<td></td>
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<td>Generate report</td>
<td>Monitor (continuous)</td>
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<tr>
<td><strong>Results</strong></td>
<td>Artifacts (constructs,</td>
<td>Constructs</td>
<td>Constructs</td>
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<td>models, methods</td>
<td>Hypothesis</td>
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<td>instantiations)</td>
<td>Descriptions</td>
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<td>and improvement of</td>
<td>Explanations</td>
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<td></td>
<td>theories</td>
<td></td>
<td>Actions</td>
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<td><strong>Type of knowledge</strong></td>
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<td>How things are or how</td>
<td>How things are or how</td>
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<td>they behave</td>
<td>they behave</td>
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<tr>
<td><strong>Researcher’s role</strong></td>
<td>Builder and/or evaluator</td>
<td>Observer</td>
<td>Multiple, due to the</td>
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<td></td>
<td>of the artifact</td>
<td></td>
<td>action research type</td>
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<tr>
<td><strong>Empirical basis</strong></td>
<td>Not mandatory</td>
<td>Mandatory</td>
<td>Mandatory</td>
</tr>
<tr>
<td><strong>Researcher-researched collaboration</strong></td>
<td>Not mandatory</td>
<td>Not mandatory</td>
<td>Mandatory</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
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<td>Not applicable</td>
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<td><strong>Evaluation of results</strong></td>
<td>Applications</td>
<td>Comparison against the</td>
<td>Comparison against the</td>
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<td></td>
<td>Simulations</td>
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<td></td>
<td>Experiments</td>
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<td><strong>Approach</strong></td>
<td>Qualitative and/or</td>
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<tr>
<td><strong>Specificity</strong></td>
<td>Generalizable to a</td>
<td>Specific situation</td>
<td>Specific situation</td>
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<td></td>
<td>certain class of problems</td>
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4.8 Design Science Research Guideline

Hevner (Alan et al. 2004) provides a seven-part guideline for conducting DSR, and all parts should be followed in order to conduct effective Design Science Research. These guidelines are not mandatory and they should be fitted to the conducted research, but all of them should at least be addressed in some way. In this research, these guidelines are addressed in the evaluation phase of the DSR method used.

The first guideline, “Design as an Artifact”, states that research must produce a feasible artifact. Here, artifact refers to a model, method, construct or an instantiation that is intended to solve an identified organizational problem. For example, this could be a piece of working software, a model of system, a language to describe a system, or a way to implement a system in a particular setting. (Alan et al. 2004)

The second guideline, “Problem Relevance”, addresses the problem and states that it must be important and relevant to a business, since the object in the information systems field is to acquire knowledge and understanding. This is especially true in relation to the community in which the research is done. For example, in a business case this could mean increasing profits or decreasing costs. (Alan et al. 2004)

This leads to the third guideline, “Design Evaluation”, which in turn addresses the requirement that the artifact must resolve the problem in an evaluable way and it must be evaluated rigorously. The reason for this is addressed in the fourth guideline, “Research Contributions”. DSR must contribute to the research community in order to be research, and since the artifact is seen as a proof of a solution, its feasibility must be rigorously demonstrated. If there is no evaluation, there is no demonstrated utility from the artifact and therefore it cannot be the evidence of a feasible solution. (Alan et al. 2004)

Furthermore, Hevner (Alan et al. 2004) has also addressed suitable evaluation methods, out of which the “Research Rigor” guideline states that the DSR must follow appropriate data collection and analysis methods. However, there needs to be balance in rigor, as overemphasis is seen to lead to decreased research relevance. This is because the artifact is supposed to perform, foremost, and excessive formalism could hinder that characteristic. For example, mathematical formalism may provide an exact
model but it is likely to lose, or ‘assume away’, some of the important parts of the problem. (Alan et al. 2004)

The sixth guideline, “Design as a Search Process”, points out that DSR is iterative and a satisfactory solution is sought. As information systems problems are inherently entangled in nature, because of the complex environment and human involvement, the optimal solution is often laborious to find and therefore a working solution or one that is good enough is already a solution. Furthermore, the working solution is emphasized over understanding why the solution works. When there is a working solution, there can always be more iterations of research on why it works. Moreover, that solution creates new questions. (Alan et al. 2004)

The final guideline, “Communication of Research”, points out that the Design Science Research must be presented well to both technologically-minded and managerially-minded audiences. The technological-minded audience needs sufficient knowledge to implement the artifact, and the managerial-minded audience requires enough detail to be able to determine if usage of the artifact would be beneficial to the context. (Alan et al. 2004)

4.9 Design Science Research steps
Dresch et.al. (Dresch, Lacerda, and Antunes Jr 2015) have performed a comprehensive summary of Design Science Research and propose a 12-step method for conducting DSR. In particular, the Dresch method was developed considering engineering, management, architecture, and design contexts. Furthermore, the approach is suited for solving problems with artifacts in the context of the problem. Although steps in the method are conducted in sequence, feedback loops exist that may occur during the process, as in Figure 3, making it iterative.
Figure 3: DSR stages with feedback loops (Dresch, Lacerda, and Antunes Jr 2015). This figure describes the stages of Design Science Research and which approach is used in different stages. Dotted lines describe iteration loops that may occur.
4.9.1 Identification of a problem
A relevant problem is identified and research for it is justified. A formalized research question is an output from this step. In this research Chapter 1, “Introduction to a research question”, addresses this step. (Dresch, Lacerda, and Antunes Jr 2015)

4.9.2 Awareness of the problem and consulting research knowledge base (systematic literature review)
This step generates a comprehensive understanding of the problem. This includes problem causes, a context and all other types of information about the problem. Furthermore, existing research knowledge of the topic must also be searched, and a systematic literature review is recommended. In addition, artifacts functionalities and requirements must be considered. The outcome of this step should be the formalization of the problem and its understanding. Chapter 3 addresses this step, with research questions from Chapter 1. (Dresch, Lacerda, and Antunes Jr 2015)

4.9.3 Identification of the artifacts and configuration of the classes of problems
The purpose of this step is to find a class, or classes, of a problem of which the research problem is a part. A class of problems is defined as an “organization of a set of problems, either practical or theoretical, that contain useful artifacts for action in an organization”. In other words, a class contains general problems that are found in different contexts, such as which research method to use in information systems research. Furthermore, solutions to classes of problems that are relevant to the research in question can be used as a source of good examples of solutions. Those solutions, sometimes artifacts, can be further improved to better confront the problem. (Dresch, Lacerda, and Antunes Jr 2015)

Results of this step should be an identified artifact and structured and configured classes of problems. (Dresch, Lacerda, and Antunes Jr 2015). This step is addressed in Chapters 1, 3 and 5.

4.9.4 Proposition of artifacts to solve a specific problem
This step involves designing a proposition of the artifact that is anchored in the problem’s local context. Adductive reasoning is recommended for the current step because creativity is important in this step. The outcome of the step should be a formalized proposal of the artifact. (Dresch, Lacerda, and Antunes Jr 2015) This step is addressed in the “As Is” and “To Be” models in Chapter 5.
4.9.5 Design selected artifact
The artifact’s internal working is designed, including its interfaces, and interactions with its environment. Furthermore, construction procedures are also described. In addition, evaluation procedures and criteria of evaluation must be clearly stated during this step. The artifact’s performance expectations are also stated. In summary, this step should state the design of the artifact and its requirements. (Dresch, Lacerda, and Antunes Jr 2015) This step is considered in Chapter 5.

4.9.6 Development of the artifact
The artifact is built and a construction heuristic is formalized from a process. This step’s results are the construction heuristic and the artifact in its functional state (Dresch, Lacerda, and Antunes Jr 2015). This step is addressed in Chapter 5.

4.9.7 Evaluation of the artifact
The artifact is evaluated against criteria specified in the “Design selected artifact” step. If the artifact does not pass the evaluation or achieve the desired effect, the research step in which failure occurred is identified and research is started again from that point. A contingency heuristic, defining limits of the artifact, and an evaluated artifact should be results of this step. (Dresch, Lacerda, and Antunes Jr 2015) This step is addressed in Chapter 5.

4.9.8 Clarification of learning achieved
Factors that contributed to research success and ones that did not are identified and reported in Chapter 5. (Dresch, Lacerda, and Antunes Jr 2015)

4.9.9 Conclusions
Results and discussions of the research are reported in Chapter 6. However, limitations of the study are reported in Chapter 1.1. (Dresch, Lacerda, and Antunes Jr 2015)

4.9.10 Generalization for class of problems
The artifact with its research is generalized using inductive reasoning to a class of problems. This benefits the research knowledge base by generating construction and contingency heuristics for a class of problems. (Dresch, Lacerda, and Antunes Jr 2015) This step is addressed in Chapter 6.

4.9.11 Communication of the result
The final step is to make the research known to interested parties, for example by publishing it in a journal or discussing it during a seminar or conference. (Dresch,
Lacerda, and Antunes Jr 2015) This step is addressed in a thesis seminar and in this thesis paper, which will be available in Aalto University’s archive.
5 Results of the study – Process and Artifact

This chapter describes a process of artifact creation resulting in an artifact itself. The chapter follows Dresch et.al.’s DSR model, continuing from the step “Identification of the artifacts and configuration of the classes of problems”, by stating classes of problems. The model is followed here until the step “Clarification of learning achieved”. Each step is conducted as described in the methods chapter.

5.1 IT artifacts

An artifact as a term is central to the Design Science Research method. Whereas an artifact is discussed here, the method of Design Science Research has its own chapter. Artifacts can be seen as something that is artificial or manmade – that is, a point in which the inner design of the artifact produces changes in its environment (Dresch, Lacerda, and Antunes Jr 2015).

Artifacts in IT are intended to solve identified organizational problems. Such artifacts are represented in a structured form that may vary from a software application, a formal logic, and rigorous mathematics to informal natural language descriptions. (Alan et al. 2004) However, in this thesis, the term artifact is mainly used to describe a software application.

5.2 Configuration of the classes of problems

The classes of problems are general problems that are not case specific even though their solutions may be.

The classes of problems identified in this thesis are as follows:

1. What are the requirements for forecast simulation, in general? What are the requirements for a financial simulation tool in the case environment?
2. What platform to use?
3. How to implement?
4. How to create visualizations?
5. How to perform drill-down analysis?
5.3 Identified artifacts

Several potential solutions to the research question that already exist and were found are discussed here. The first found artifact is Oracle's Instantis Enterprise Track. It seems to provide similar capabilities to those that are needed in developed artifacts. For example, according to its website, it has drill-down capabilities, dashboards, and resource allocations and it seems to generally perform similar, needed functions. (“Primavera Enterprise PPM - Products | Oracle” 2015) However, this solution was not examined thoroughly, but it may contain good solutions and examples.

ARIS appears to have the capability to build a calculation system into it and through that modifiability, it performs as a platform to the solution. (“Overview - ARIS | Governance, Risk & Compliance” 2015) However, there seemed to be little to learn from this solution.

These are large solutions that have high costs and provide functionalities that are beyond what is searched for here. Furthermore, learning their implementation would require more thorough investigation and access to them; both are outside the scope of this thesis. Furthermore, more thorough research for solutions could be performed as well.

For example, Promodel also seems to provide some needed capabilities (“ProModel - Technology Enabled Predictive Analytics Simulation” 2015). Furthermore, it is likely that there are multiple corporate software solutions for the problem. However, there have been few scientific articles published about them. This could be a result of the quickly advancing field; research papers can’t keep up, since in some cases new updates with new functionalities are released monthly. Furthermore, research about these solutions is outside of the scope of this research study.

5.4 Proposal of artifacts to solve a specific problem

Following the grounded theory approach, the current situation is assessed through interviews (attachment interviews 1-7) of related people, incidental comments from company personnel and information from the company database. In addition, a tool that was previously used to process data from projects is studied. Based on the assessment, an “As Is” model is constructed.
A “To Be” model is designed based on the “As Is” model, gathered knowledge, interviews 1-7, incidental company expertise, and previous experience of the researcher.

5.4.1 “As Is” model
A schedule of 10-year strategic planning of ICT projects is visualized in static graphs in a PowerPoint document. Graphs are created in Excel and numbers are in millions of euros. A Excel document itself is old, taken into production use in 2012, and it was initially designed for a slightly different need and has been modified to suit current needs. Therefore, it contains fields and multiple calculations that are no longer used.

Furthermore, the Excel workbook is used for annual budgeting and is updated at most once per year. Updating is done by requesting numbers from relevant people and systems and by estimating. A significant part of this process is a copy-paste action. Realized accounting information is gathered by the ICT controller from a PFM (Portfolio Management) system, summed up, and added to the Excel spreadsheet.

Estimation numbers are gathered from persons responsible for project initiations or are estimated. In addition, short-term (<15-month) planned expenditures are used from the PFM system, which is updated by project managers.

Currently, small-scale planning is handled separately and a summary of this information is collected from a person maintaining a list of these costs.

When numbers have been inserted in the Excel spreadsheet, they are in the form of project/year and are in millions, rounded to two decimal points. Further, numbers are summed into categories and visualized in a costs/year graph, which is presented in PowerPoint slides as a picture.

Timeline, connections between projects and execution order, is visualized in Aris as a roadmap. However, this roadmap does not contain numeric information.

Work effort estimation is also done in Excel and calculated as a Full Time Equivalent (FTE), which means one internal person’s full-time work effort during a time period.
FTE is mainly estimated based on projected costs, since direct estimates of FTEs are rarely available.

5.4.2 “To Be” model
The purpose of this research is the creation of a flexible, visual and easy to use tool, an artifact, for simulating investment possibilities in IT, in order to support strategic decision-making in the case company. Arising from the mentioned purpose, the “To Be” model is constructed based on the “As Is” model and needs to be identified through discussions conducted by the grounded theory methodology.

The transition to rolling forecasting makes the old Excel spreadsheet an unviable solution, as it takes a significant amount of time to update, and it is therefore unfit. Furthermore, it is seen as something that could be improved with lesser effort to better answer the needs of strategic management and ITC management.

Focus is also on easy gains, since the main part should be doable in the thesis effort timeframe. Furthermore, unimplemented identified needs are left to future expansion of the tool, thus design should be extendable. However, requirements based on the old tool are priority since the old tool needs to be replaced.

Requirements that are based on the old artifact:

- The new system replaces the old Excel spreadsheet in a new rolling forecast environment with viable solution that has the same or higher capability.
- Particular interest is in big projects with a size of 1 million EUR, and small projects, if not seen as exceptionally important, are combined into one “summary project”. However, there should be a possibility to evaluate smaller projects, if the need arises.
- The solution should visualize the forecast Cost and FTEs.
- A viable solution is needed to manage and simulate very long-term, large-scale projects with 10-year timeframes that have not yet been approved and inserted in the project management system.

New capabilities were identified for implementation:
• Improve forecast accuracy for both FTE and COST
• Add a way to zoom into different levels and organize based on different criteria (drill down)
• Categorizations of projects based on business area, business capability, phase of project, and other categories
• Model must take Uncertainty/Risk into account in sufficient detail
• Categorizations of projects based on project cost estimation
• Tool should not be complicated to use and it should be primarily visual
• The tool is designed to be modular and extendable, flexible for future development
• Able to combine data from different sources to make comparisons
• Provide a platform that facilitates holistic understanding of costs
• Increased transparency
• Enable holistic management of costs of planned projects as a whole

Philosophies of the tool are: easy to use, easy to implement, flexible, modular, need to outperform the old system, and be a feasible system in the rolling forecast budgeting process.

Most of the initial data processing needs that were identified through interviews and examination of the old tool were met by Excel pivot tables and graphs. However, enabling this created the need for a structured data table that is not easy to read or update.

5.5 Design selected artifact
This subchapter describes the design of the artifact and its internal workings, interfaces, and interactions, divided by different parts of the design and the needs fulfilled. Furthermore, artifact construction procedures are described along with evaluation criteria and performance expectations.

5.5.1 Platform choice: Microsoft Excel 2013
A variety of platforms to choose from exists, such as Microsoft Excel, Aris, Mathlab, or for example the possibility to code from scratch. Platform choice has effects on
design, functionality, usability and future extendibility of the artifact. Microsoft Excel was chosen to be the implementation platform because Excel is already widely used in the organization and it is a flexible tool that could provide all the necessary functions of a platform. Furthermore, the organization already has the 2013 version of Microsoft Excel with PowerPivot, which provides extensive data crunching functionality in Excel. In addition, Excel’s VBA programmability provides even more flexibility. Moreover, the main goal of this research is to replace the old artifact; since it had been implemented in Excel, the choice is safe. This is even more so when considering that the old solution was not using PowerPivot nor VBA and has been designed on Excel 2003 or older.

Moreover, Microsoft Excel is a cost-effective way to create at least a prototype of a needed model and test it. Furthermore, Excel is widely used in organization and there is no learning curve to it’s use, if its base functionality and interface are maintained. However, for VBA and PowerPivot some effort in learning is required from the researcher.

5.5.2 Data sources
The realized cost data source is a Portfolio Management (PFM) system that contains financial data of projects on a monthly basis. Furthermore, the PFM also contains short-term project cost estimations. However, this system is limited by a project approval system that forbids inserting forecasts longer that the term for which the project has been approved. Therefore, the PFM contains only information on approved expenditures and no information on possible future spending nor information on projects that are not yet approved for any term. The PFM also does not have information on small projects under 50 000 EUR although there are plans to change this situation. Nevertheless, the PFM is used as a source of realized cost data. Furthermore, it was determined that the PFM contains interfaces that would potentially enable automatic data retrieval from it, although this potential option is left to future extensions of the artifact.

However, estimates of projects that have not yet been accepted for implementation exist only with the people who are designing these projects. Therefore, the only way to acquire these estimates is obtaining them from these people themselves.
5.5.3 Risk
In the company’s system, project costs are initially estimated with an accuracy of total cost being in the range of +/- 40% of estimated cost. These estimates are typically made when the project is about to be started approximately 16 months in the future. However, in this case, the main interest is on a much longer timeline, up to 10 years in the future. Furthermore, estimation variation is high when considering long-term projects, and if a 16-month estimate can be 40% accurate, numeric value accuracy estimates quickly become meaningless with longer timeframes. Consequently, it was determined that for the purpose of this tool, risk will be taken into account as a category in which projects are assigned a value that is based on the same data source as the estimation.

Three meaningful categories for the company were found. The first is a bid from a supplier to complete a project. This is a quite solid estimate, as cost will not change if the bid is accepted. The second category is a market estimate of a bid. This is an estimate of the price that the market would deliver to the project based on similar cases. The last category is the expert estimate, which is based on specialist opinion of total cost, which is likely to be the least accurate but nevertheless better than a non-specialist estimate.

5.5.4 Drill-down pivoting
Drill down is a concept in which, starting from a summary of data, it is possible to go back into parts of the summary or to original data used to produce the summary. In essence, to drill down is to see what the parts are of which the summary is made. This is a major contribution to transparency, since data on which estimates are based is available with ease. Drill capability of the tool is foremost limited by the capability of the platform, Excel, and the data resolution of the tool. The resolution is chosen to be on a level of project/month and this choice is discussed in the “Database design” section. Furthermore, drill down includes the idea of filtering and showing only some costs. For example, sometimes it is necessary to show only certain projects or certain projects based on tags, timeframe or other identification criteria.

5.5.5 Data processing in Excel and PowerPivot
Microsoft Excel Pivot options provide a good solution to summarize data from a database. Furthermore, data tables can be updated and a simple refresh will calculate
a new summarization from the data. This includes graphs that are similarly updated in real time based on updated data. In addition, slicer options provide the ability to filter data based on criteria. This option is also easy to use since it allows the creation of interactive buttons for a user to apply filters to data in real time. A dashboard view generated by this solution is presented in Figure 4 below.

Figure 4: Picture of dashboard. Dashboard provides slicers, project name, business capability, business area, custom information, date and size, to slice data and drill down into any combination level that occurs by combining different slicer choices. Data is provided according to slicers in a numerical summary and as a visual graph.

Excel’s built-in pivoting tools enable the aforementioned abilities to view only one table but with limited options. However, the PowerPivot add-in removes these limitations and further extends the capabilities of Excel. PowerPivot enables filtering tables based on another table as well as custom calculations in the pivoting tool, and it extends Excel’s ability to handle and utilize big databases. In essence, PowerPivot creates its own data model based on data from different, connected tables and uses the model to perform calculations. This model is flexible, since modifications can be made directly into an Excel file and after a refresh, all data and structure modifications are in pivoting use. (“Create a Memory-Efficient Data Model Using Excel 2013 and the Power Pivot Add-In” 2015)
In this artifact, PowerPivot is used to combine seven different data tables into one data model, which it uses to perform calculations. These tables are described in the section “Data database and input design” and are presented here only in their relation to PowerPivot. MasterDataTable is used for numeric data containing cost realizations and cost estimates in various categories by month by project and with project codes and primary key columns that are used to make rows unique. ProjectTags, a data table with tags, is used to create a slicer with different categories, and this table is able to be updated with new categories, enabling the easy addition of slicers. Similarly, a timeframe slicer is created by adding date table dCalendar in the model, which allows time categorizations. When using just one data table built-in feature in Excel, the pivoting tool automatically creates a timeline filter, but with PowerPivot and multiple tables, a date table that can be used for a similar timeline filter must be manually created.

Size estimation categorization requires three data tables. The first table is to provide the size category and the other two are to provide separate names for those categories for FTE and Cost estimates, since they need different labels to provide clarity in visualization. Furthermore, size categorization is based on data from the data table and is therefore automatically updated if project cost moves the project to a new class. Implementation of this uses DAX functions that PowerPivot understands and uses to analyze data. In essence, the total cost of a project is calculated, a category is assigned to it, and finally a name is given to a connected category from the category name table. This results not only in automatic categorization, but it is also possible to use it as a slicer. For example, this solution can display all projects that cost 1-2 million EUR, if the corresponding option is checked.

However, the solution for this functionality is somewhat clumsy because it is trying to avoid the limits of PowerPivot, since it cannot handle circular references. In order to make the size categorization work, a primary key column is added to the monthly data table. This key column identifies unique rows to PowerPivot and enables it to calculate summaries and organize data based on a project name or code. Separate categorization is also created in order to avoid circular reference. If those tables were connected, PowerPivot would first calculate size category based on a table and then use the same table to name or filter those categories. This is restricted in PowerPivot. Part of this
The problem is also that it is difficult to create a categorization that would directly provide the name of a category instead of a number in DAX functions.

Furthermore, the aforementioned solution crashed randomly for unknown reasons and a new workaround was designed. The DataYearly table was added into the model to break the circular reference warning. In this solution, everything works similarly to the previous solution except that cost estimate numbers are taken from the DataYearly table. This does not create a circular reference because the DataYearly table is updated with VBA based on the MasterDataTable and there is no visible connection to the PowerPivot engine to notice. The downside to this solution is that now both the MasterDataTable and the DataYearly table need to be up to date when performing calculations.

Visualization is built into the PowerPivot data model as well. In essence, the Excel pivot function uses the data model from PowerPivot, enabling the creation of graphs that use data from all tables in the model. Furthermore, these graphs are automatically recalculated if data in the tables change or slicers are modified. However, the use of the update button is recommended, as some changes might not be otherwise updated in the model.

5.5.6 Database and input design
In the previous tool, data is estimated on the level of project/year/cost, from which a solid summary estimate is calculated using all source data. Consequently, more precision is demanded from the new tool in the form of the possibility to access the data that has been used for calculations.

In the PFM system, financial data is at the level of project/month/cost. As a result, the most precise rational drilldown in the tool must be the precision of the project/month/cost level of data, because increased precision would require a new kind of PFM system. Furthermore, this precision is high, since a monthly forecast for strategic planning is rarely needed. However, as added precision to the pivoting system does not create added difficulty in processing design, it was decided to design the new tool with PFM precision. This choice was also seen as beneficial if automatic dataflow from PFM would be implemented.
However, this level of precision creates a database that is tedious to edit without additional tools. Furthermore, it is likely that a lot of information needs to be manually updated in the database since the old tool was already highly reliant upon a user. In order to improve this situation, the option of automation should be left open in places where it is possible, in order to decrease manual labor.

Based on reasoning outlined in previous chapters, a database was created. Foremost, the database was created to support pivoting functions as much as possible. For easy implementation, these functionalities require the database to be arranged so that the data is stored in rows, and columns work as data fields. This is also a good choice because it simplifies automatic data import from databases, since databases often use this type of tables. However, this creates a database that is unintuitive for the human user and does not enable manual updating as easily as the previous tool did. To assess this problem, Excel VBA was put into use.

The database is designed as a two-level system in order to make data input more user-friendly. One summarizes projects on a yearly level (Figure 6) and the other on a monthly level (Figure 5). Furthermore, these tables are intended to preserve all Excel functionalities, thus allowing users to add and delete data as if tables were just separate tables, as long as the original columns are not moved. In data analysis only the monthly table is used. These sheets synchronize and enable both to be updated with input to just one. This functionality was enabled by VBA code and pivoting.

![Figure 5: DataBase Table. Presenting data in monthly form.](image-url)
Figure 6: Data Yearly Table. Presenting data in yearly form.

Updating from a monthly to a yearly table is a straightforward summarization with the Excel pivoting function and copying results to the table with VBA from all projects. However, when going from a yearly to a monthly table, VBA and calculations are needed. In essence, user input is needed to determine which project is updated from yearly to monthly, and costs are equally divided among months; all previous data is overwritten (Virhe. Viitteen lähdettä ei löytynyt.).

Equation 1:

\[
\text{Yearly cost} = \frac{\text{cost}}{12} = \frac{\text{cost}}{\text{month}}
\]

This overwrite function results in a loop that could destroy data quality. For example, when monthly data is imported into the yearly table, years are summarized from data. However, if data is then subsequently exported back to a monthly table, the original data in that table is overwritten with the yearly summarization divided by 12. Consequently, tables cannot be fully automated and when the data is imported, the user is asked which project is updated from the yearly table. For this reason, the yearly table contains buttons to control the updating and deletion of data, an import and an export button, as in Figure 7.
In the yearly table there are also ‘delete’ and ‘input data’ buttons. The delete button removes all rows containing project data from data tables based on a project code entered by the user. The input data button opens the input panel (see Figure 8: Input Panel picture) that that fills project data from time and total cost estimates inserted by the user in the DataYearly table. The panel is implemented with VBA and Excel’s built-in panel function. This works similarly to synchronization as project costs are equally divided over years as in Equation 2 (Total cost / project duration in years = cost/year).

Equation 2:
There is an additional data table in the ProjectTags sheet (Figure 9). This table contains information about to which company’s internal categorization the project belongs. The table enables different filters and categorizations of projects by different types, such as departments, risk levels, business areas, or any other category meaningful to the company. This table is also designed in such a way that updates can be made directly to the table. However, changes in this table affect the data model in PowerPivot and, as a result, an update button has been added. This button updates the data model, and changes in this table are updated to all visualizations and summaries. Furthermore, if new columns are added or old columns moved, it is a simple process.
to use them from the pivoting function; deleting them just removes them from all calculations and no further action is required.

Figure 9: ProjectTags sheet. Project tags sheet collects information that is used to drill down into projects.

In order to create a size categorization, a “size class table” was constructed for both FTE and Cost (Figure 10). This table enables PowerPivot to automatically assign a correct class to a project even if its data changes, so that a project moves within category. A size class contains categorization in numbers, and minimum and maximum values that belong to a certain class. Name tables contain names corresponding to a class number (Figure 11). These tables can be updated directly as well; however, in normal use they are hidden in order to simplify the interface by having fewer sheets visible. Although hidden, it is easily accessible in Excel with the “Unhide sheet” command while right clicking on tables.

Figure 10: Size Class Table. This table defines size classes that can be used for drilldown purposes.

Table 1: Size Class Names. This table defines names for the size classes.

For a date categorization, a separate date table was created since PowerPivot doesn’t support automatic date categorization with multiple tables. This table is a simple table of monthly dates, for example 1.1.2030. There should not be any need to make changes to this table unless a project’s timeline goes beyond 2030. If the need arises, it can be extended directly, and the only negative consequence to this action is that it expands a date slicer length, which makes it look more complicated. In addition, this table is hidden in normal use, similar to the class categorization tables.

5.5.7 Artifact user view
Use of the artifact is divided into two uses: “update and management of the artifact” and “visualization”. While visualization is simple, the update and management use requires basic understanding of Excel. In addition, visualizations are in yellow sheets and update and management actions are in red sheets, as shown in Figure 12: Sheets.

Figure 12: Sheets. Sheets are color coded as yellow for visualizations and red for management of data.

Artifacts visualizations work in yellow sheets, namely: Roadmap Cost Estimate (see Figure 4: Picture of dashboard) and FTE Cost Estimate. Both of these have the same basic structure; the main difference is that one uses cost data from the database sheet and other uses FTE data. The overall design is simple and no special knowledge is required to use visualization.
Visualization sheets contain graphs, pivot tables, slicers: timelines and size, and an update button. Graph (Figure 13) provides a staked column chart of the data while a pivot table (Figure 16) provides that data numerically. Furthermore, the graph and pivot table are updated in real time according to selected options. Slicers (Figure 17) filter data according to a selected slicer option, such as project name or other categorization of project present in the project tags sheet. Timeline (Figure 14) and size categorization (Figure 15) work similar to slicers but obtain their information elsewhere. Timeline slicer (Figure 14) selects a timeline presented in the graph and the pivot table. Size categorization (Figure 15) allows the selection of a project of certain size group to be presented in the graph and the pivot table. In addition, all these selection options can be used simultaneously, and systems show only filters that are present in the data, graying out those that are already filtered out by other filters. For example, if only the year 2017 is selected, projects that are not implemented in that year are grayed out. Finally, an update button (Figure 18) updates the internal model of the tool to use the latest data from the data sheets.

Figure 13: Graph. Dashboard graph of data in real time, reflecting slicer choices.
Figure 14: *Timeline*. Timeline slicer is used to select a time period of interest.

![Timeline Diagram](image)

Figure 15: *Size categorization*. This slicer is used to select project sizes that are of interest.

![Size Categorization Diagram](image)

Figure 16: *Pivot table*. This table displays numbers based on slicer choices.

![Pivot Table](image)
Figure 17: Slicers. Slicers enable real-time drill down into data.

Figure 18: Update Button. The update button enables the user to synchronize inserted data between sheets.

Update management of the artifact is conducted in the red data sheets, namely ProjectTags, DataYearly, and DataBase. ProjectTags consists of the categorization information of projects. DataYearly has yearly summary information of projects and buttons to help editing. DataBase consists of monthly data of projects. The concept is that each responsible business area is updating its own information. Furthermore, they can also use visualization to see their own area’s situation. In contrast to visualization, data management requires some Excel knowledge and little understanding of how the data management works in the tool.

In essence, data management works as an Excel data sheet, but it has some functions that intend to make it less tedious. For example, in tables, data can be directly edited and rows can be added or deleted. From the DataYearly sheet (Figure 6), a new project can be added with a new project button (Figure 7), which produces a form (Figure 8) to complete with the details of the new project and moves those details to the ProjectTags, DataYearly and DataBase tables. From the DataYearly table, data can be
exported to DataBase with an export button. The Export Data button exports project from DataYearly to DataBase based on user-inputed project code. Similarly, an Import button imports database data to the DataYearly sheet. This requires no user input, as database data is considered to be master data. In addition, a Delete button deletes a project from the database based on the user-inputed project code. All the aforementioned buttons are illustrated in Figure 7: Buttons in the yearly table.

One thing to keep in mind when editing the database is that DataYearly works only as long as estimation is on a yearly level. Updating from there will change DataBase data to match DataYearly. For example, if a project lasts only part of the year and it is updated from Database to DataYearly, and then back to DataBase, the project has been updated to last an entire year.

5.5.8 Future development
Interviews, design, and construction phases resulted in development possibilities that could further enhance the capability of this type of tool. Here, those are listed with implementation ideas for some of them and reasons why they should be implemented, if not obvious:

- Use SharePoint to share the document and possibly use SharePoint features to enhance the capabilities of the artifact.
- Adding estimated and realized revenue could further extend the tool. Furthermore, this could be a simple addition of a separate table or adding data columns to existing tables with a new visualization sheet.
- Data gathering from PFM into the tool could be automated through existing interfaces. This would also decrease the amount of reporting and create a possibility to compare estimates to realized values with little investment of time. Furthermore, data quality would improve as well as automating copy/pasting.
- What if analysis: There could be a possibility to create a better environment for scenario design. Projects that are in the planning phase could be duplicated with different start and end dates. For example: original project, start date +1, +2. Then the user could filter different versions of the project to see which timeline suits it best. Furthermore, this design could be expanded with Excel’s built-in solver to discover which projects to conduct in order to create as little
variation in yearly cost as possible. Similarly, any other solver-compatible rule could be applied.

- Mathematical graphs could be used to assign costs instead of using a flat model. This could be achieved by altering how the new project divides costs. Further, comparing forecasts to actual results and using this information to improve new forecasts and predict new project costs would be possible. However, its implementation would require VBA functions.
- Currently, comparing a certain project to the entire portfolio is clumsy and the process could be improved. Such a comparison might be having a graph of all projects and some selected projects in the same chart. This might be implementable through the creation of a summary project that contains all projects and adding it as a separate project to the model.
- Interconnections of projects could be taken into account, however ARIS is providing this information and no actual need was detected.
- Record changes in estimates to see how estimates change and to display changes in projects.
- Include people in FTE calculations to avoid the overbooking of resources.
- Based on data gathered in this thesis, the use of another platform to develop a solution may be desired.

Some developments that are outside of this artifact but could potentially be valuable include the following: Future projects could benefit from some universal code that would stay the same throughout the development, as it was discovered during discussion that a project could be referred by multiple different names resulting confusion or loss. Furthermore, data could be better integrated and made available to be used in pivoting-style analysis for all who need it. In addition, in long-term development view, ARIS seems to have some unused potential that could be a similar platform, like Excel is to this artifact, but on a much larger scale.
5.5.9 **Evaluation criteria artifact and research (process)**

Evaluation criteria for the artifact are formed as follows:

1. Replaces the previously used tool
2. Fulfills additional needs
3. Creates a base for future developments / is extendable
4. Identifies possible development opportunities
5. Continuous evaluation with company during development
   a. During development
   b. First version in use
6. DSR Guidelines (by Hevner) are followed
7. DSR process (by Dresch) is followed

The research process is following the DSR steps from Chapter 4.9 with multiple iteration between steps. Furthermore, the main limitations of the artifact are described.
5.6 Development of the artifact

Based on platform choice, the iterative grounded process of creating the tool was performed. A significant part of this process was the researcher learning Excel capabilities, finding good solutions to implement requirements and identified needs, and discussion in interaction within the company. Furthermore, interviews were also held during the process.

The focus was on the tool’s visual and presentation capabilities, and therefore design started from visualization needs and moved in the iterative process to fulfill the needs that those designs created. This process led to selection of the design of the artifact.

Furthermore, the introduction of an incomplete artifact to the company was also used in design in order to make sure the solution works in the company environment. This was mainly conducted in interviews.

A systematic literature review was also conducted in order to make sure that relevant scientific information is in use and that the literature surrounding the topic is better understood.

As a result, an Excel document has been created as an artifact, as well as a Master’s thesis that describes the research.

5.7 Evaluation of the artifact and contingency heuristic

The artifact is evaluated against the criteria specified in Chapter 5.5.9. If the artifact does not pass the evaluation or achieve the desired effect, the research step in which failure occurred is identified and research is iteratively started again from there.

Final evaluation of the artifact based on previously defined criteria is as follows:

1. Replaces the previously used tool:
   The tool is capable to replace the previously used tool.

2. Fulfills additional needs:
   The artifact provides ways to drill down and visualize data in ways previously not possible.
3. Creates a base for future developments / is extendable:
   The tool has multiple ways to be extended as described in the Future
development chapter.

4. Identifies possible development opportunities:
   Further development opportunities that were identified during development of
   this artifact are described in the Future development chapter.

5. Continuous evaluation with company during development:
   a. During development:
      Interviews 8-12 were used to validate the design before testing the tool
      with company data.
      Interviews 13 and up were conducted to test the tool in the organization.
   b. First version in use:
      Final in-use test evaluation was not performed.

6. DSR Guidelines (by Hevner) are followed:
   DSR Guidelines were followed as described in this thesis.

7. DSR process (by Dresch) is followed:
   DSR process was followed as illustrated step-by-step in this thesis.

Contingency heuristics or the main limitations of the artifact are that: it is complicated
to use without understanding the artifact as described in the user view chapter.;
currently the artifact is only one Excel file and easy collaboration is not possible; the
artifact requires Excel and PowerPivot to work; and modification of the artifact
requires a good understanding of Excel, VBA and PowerPivot.

5.8 Clarification of learning achieved
Factors that contributed to research success and ones that could improve future
research were taken into account.

Factors that contributed to this research:

- Supporting people
- Continual learning and search for information
- Good manual
- Iterative design process
• Going to Excel implementation even though a lot of information was still missing. It revealed questions that were not apparent and enabled the design of a better user experience.

• Writing thesis helped to process information and created a more clear understanding of the artifact, problem, solution, and research area.

• YouTube for learning Excel, VBA, and PowerPivot.

Factors that should be better taken into account in future research:

• Involving more people, more often to find a relevant previous solution.
• Using a tool such as Zotero to manage found research and citations.
• More push and bold moves by researcher in the interest of this project could have sped it up and resulted in a better tool.
• Increased focus on which features are the most important.
• More information from the industry on tools that could solve this problem; no research was available, although these solutions are not likely to be free and easily configurable by a company, resulting in high implementation costs.
• Drilldown creates the need for detailed high-resolution data that is tedious to manage and enter into a system.

The design emerged from multiple ideas by choosing a solution to problems, which in turn limited a future option. Furthermore, multiple possible developmental options were dropped in order to fulfill one specific purpose of the tool.
6 Conclusion

This chapter reports the results of the study and provides further discussion of the topic. In the beginning of this chapter, the study is generalized using inductive reasoning in order to produce information that could benefit other cases besides this one. Moving on from that topic, the main findings of the study are reported. Then the area of the study is discussed and, finally, future research is proposed.

6.1 Generalization for class of problems

General classes of problems for this research were defined in Chapter 5.2. In this chapter, solutions to general problems suggested by this research are presented.

1. What are the requirements for simulation, in general? For a financial simulation tool in the case environment?

The most important requirement is that the data is easily generated or captured. For example, the artifact could handle most of the requirements but making the insertion of data easy, simple or automatic is difficult. Especially the 5th general problem “How to perform drill-down analysis?” generates an extensive need for data and therefore there is no workaround for the data requirements. The only real solutions to this problem would be the automation of tools that already contain the needed data, or that a simulation tool itself would essentially be the platform to do design work and data is the side product. For example, a platform where projects are planned is designed to aggregate data that is inside those design plans.

2. What platform to use?

Excel is a working solution; however, others might be better if resources are available. Furthermore, the Excel resulting from this study is relatively complicated and with more features it could be too complicated for the non-specialist.
3. **How to implement?**

   The solution in this research could be performed by a single person, assuming one person updates data. However, in a more likely scenario where data is collected directly from users and if data integration is not possible to make into tools currently in use, organizational change is required to adopt new tools and the processes that those tools will bring.

4. **How to create visualizations?**

   Creating visualizations is easy and fast, at least with Excel, and basically all needs could be met, even with much larger data sets. This makes it relatively easy to solve problems. In addition, multiple other solutions exist, such as Microsoft power BI or Qlickview.

5. **How to perform drill-down analysis?**

   Drill-down analyses are similarly to visualization in that they are relatively easy to create with Excel’s PowerPivot, provided there are data and the amount is not in the tens of millions of data points. However, drill-down analysis creates difficulties in the amount of available data it requires, especially when that data needs to be updated. This emphasizes the question of what data is really needed? Nothing more should be used, and likely less.

6.2 **Academic contribution of the study**

   This study provides the answer to the question, “How can the case company use enterprise architecture–based simulation in strategic investment planning?”, in the form of an artifact and a development path that leads to it. That path is described in this research paper.

   This study generated classes of problems that were further narrowed down as a result of this research. The main problem remaining after this research is: how to capture data.
Initially, SLR results on the topic were poor, as only two articles were found that significantly support the study. Furthermore, no tool example was found. However, SLR combined with articles found otherwise resulted in the interesting discovery of two separate lines of research that, if combined, could result in advancement of the theory on how to manage a motioning system in EA with architectural control points. Therefore, studying a motioning system with architectural control points would make a good research topic.

Furthermore, DSR and SLR proved to be effective methods for this type of research.

6.3 Practical findings of the study
This study provides an example of a practical tool, based on Microsoft Excel, used to create a simulation of strategic investment planning. Furthermore, the study also provides the process that generated it with learnings that arose from this study.

This study was done in an ICT context. However, no reasons were identified why a similar solution would not work in other fields of project planning. Additionally, a similar solution could work even on a bigger scale and have similar challenges. Furthermore, specifications identified could be used to configure another platform besides Excel.

6.4 Discussion and Reflection
The design and development of the tool proved to be much more challenging than initially thought. This type of tool seems to be on the crossing point of many different fields and areas that have their own fields of research, such as risk management, strategic management, project management, project and portfolio management, business intelligence, user experiences, collaboration, and different fields of EA. During this research, multiple problems from different areas arose and they would have each required research on their own.

For example, with uncertainty analysis, the research quickly runs into trouble. When various numbers are estimated, their cumulative uncertainty could be lost, resulting in
approximation. This could lead to uncertainty being at the same scale as approximation itself. In a way, drill down analysis tackles this issue because it provides easy access to more accurate numbers. However, this will still not solve the problem. IT merely allows the identification and evaluation of estimates.

Furthermore, many more iterations are required in order to create a truly good solution and, even then, technological development is likely to provide more room for development, as for example Excel 2016 already provides better tools to generate future predictions, and thus no custom-made code would be needed.

MS Project Online is offering capabilities that respond well to the demand for this type of tool, although for visualizations it should be connected to Excel, power BI or a similar system. For example, of the development list generated by this research, Microsoft Project can fulfil the following:

- Estimated and realized revenue;
- Data gathering from PFM into tool could be automated through existing interfaces;
- What if analysis;
- Mathematical graphs could be used to assign costs;
- Currently comparing a certain project to the whole and optimizing portfolio;
- Record changes in estimates to see how estimates change and to display changes in projects;
- Include people in FTE calculations to avoid overbooking resources;
- OData link to other systems for data being used elsewhere.

There are other capabilities as well. Furthermore, if UMT 360 is enabled, most project finances could be performed with an MS project–based solution with full ERP integrations. In theory, this enables the project manager to conduct all project management activities in one tool and omit all reporting activities. Furthermore, this would be basis of true portfolio optimization, getting rid of unused allocated resources and putting them to use where more are needed. This creates visibility throughout the portfolio and therefore allows the rise of accountability when assumptions, forecasts, and results are visible and therefore able to be evaluated.
However, the system cost would be much higher and organizational change would still need to be carried out, as MS project or MS Project Online should be used for project planning in order to automate data gathering in this way.

### 6.5 Recommendations for further research

1. What would a combination of two found research fields, chapter 3.7.2, result in?
2. How do organizations perform ITC project planning on a 5-10-time scale? What commercial tools are available for this purpose and what capabilities do those have?
References

Literature


Merriam, Sharan B. 1998. *Qualitative Research and Case Study Applications in Education. Revised and Expanded from“ Case Study Research in Education.”*. ERIC.


Interviews


Appendices

Appendix 1: Structure of semi structured interview 9-12

Semi-Structured interview after presenting the tool 30 min
1-2 persons at time 4 interviews in finnish.

For what purpose would you use the tool?
(Mihin käyttäisit? )

What is good?
(-mikä hyvää )
What should be improved?
(-mitä parantaa?)
What could be made better?
(-Miten olisi parempi?)
Any other thoughts?
(Ajatuksia?)

Appendix 2: VBA Code

6.6 General code

Sub Add_New()

Load UserForm1

UserForm1.StartUpPosition = 0
UserForm1.Top = Application.Top + 165
UserForm1.Left = Application.Left + Application.Width - UserForm1.Width - 165
Public Sub DeleteProject()

Dim oRange As Range
Dim Targ As Variant

Targ = InputBox("Project Code")
If Targ = "" Then Exit Sub

'Delete from DataYearly'
Do

  Set oRange = Sheets("DataYearly").Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
    Lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
    MatchCase:=False, SearchFormat:=False)

  If Not oRange Is Nothing Then
    oRange.EntireRow.Delete

  Else
    Set oRange = Nothing
  End If

Loop

End Sub
End If

Loop While Not oRange Is Nothing

'Delete From ProjectTags'

Do


If Not oRange Is Nothing Then

    oRange.EntireRow.Delete

End If

Loop While Not oRange Is Nothing

'Delete from DataBase'
Do

    Set oRange = Sheets("DataBase").Columns("A").FIND(what:=Targ,
    LookIn:=xlValues, _
    lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
    MatchCase:=False, SearchFormat:=False)

    If Not oRange Is Nothing Then
        oRange.EntireRow.Delete
    End If

    Loop While Not oRange Is Nothing

'Updates RowNumber so that first row in DataBase table starts with 1

    Call AddPrimaryKey

    MsgBox "Deleted"

End Sub
Public Sub ExportProjectToDataBase()

Dim ws1 As Worksheet: Set ws1 = ThisWorkbook.Sheets("DataYearly")
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("DataBase")

Dim iRet As Integer
Dim strPrompt As String
Dim strTitle As String

Dim firstAddress As Variant
Dim oRange As Range

Dim Targ As Variant
Targ = InputBox("Project Code")
If Targ = "" Then Exit Sub
'Test if there is already project with same code in pivot table'

Set oRange = ws2.Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
MatchCase:=False, SearchFormat:=False)

If Not oRange Is Nothing Then

' Prompt

strPrompt = "Already exists in DataBase. Overwrite Data?"

' Dialog's Title

strTitle = "My Tite"

iRet = MsgBox(strPrompt, vbYesNo, strTitle)

' Check pressed button

If iRet = vbNo Then
    Exit Sub
Else
'delete data from database'

Do

    Set oRange = Sheets("DataBase").Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
        lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
        MatchCase:=False, SearchFormat:=False)

    If Not oRange Is Nothing Then
        oRange.EntireRow.Delete
    End If

Loop While Not oRange Is Nothing

End If
End If

Dim LASTROW As Long
LASTROW = ws2.Cells(Rows.Count, 1).End(xlUp).Row

Dim FREEROW As Long
FREEROW = LASTROW + 1

Dim Code As Variant
Dim Name As Variant

Dim Year As Long
Dim sDate As Date

Dim BCE As Double
Dim ICTCE As Double
Dim BOE As Double
Dim ICTOE As Double
Dim BFE As Double
Dim ICTFE As Double

'does it exist in Yearly? if so; saves the location to oRange'
Set oRange = ws1.Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
MatchCase:=False, SearchFormat:=False)

If oRange Is Nothing Then
    MsgBox "error dose not exist"
    Exit Sub
End If

firstAddress = oRange.Address

Do

    Code = oRange.Value
Name = oRange.Offset(0, 1).Value

Year = oRange.Offset(0, 2).Value

BCE = oRange.Offset(0, 3).Value

ICTCE = oRange.Offset(0, 5).Value

BOE = oRange.Offset(0, 7).Value

ICTOE = oRange.Offset(0, 9).Value

BFE = oRange.Offset(0, 11).Value

ICTFE = oRange.Offset(0, 13).Value

sDate = DateValue("1/1/" & Year) 'Ei toimi surfacen officessa 1.1. muodossa???'

ws2.Rows(FREEROW & ":" & FREEROW + 11).EntireRow.Insert

Dim i As Integer

For i = 0 To 11
ws2.Range("A" & FREEROW + i).Value = Code
ws2.Range("B" & FREEROW + i).Value = Name
ws2.Range("C" & FREEROW + i).Value = DateAdd("m", i, sDate)
ws2.Range("D" & FREEROW + i).Value = BCE / 12
ws2.Range("F" & FREEROW + i).Value = ICTCE / 12
ws2.Range("H" & FREEROW + i).Value = BOE / 12
ws2.Range("J" & FREEROW + i).Value = ICTOE / 12
ws2.Range("L" & FREEROW + i).Value = BFE / 12
ws2.Range("N" & FREEROW + i).Value = ICTFE / 12
Next i
FREEROW = FREEROW + 12
Set oRange = ws1.Columns("A").FindNext(oRange)
Loop While Not oRange Is Nothing And oRange.Address <> firstAddress

'Updates RowNumber so that first row in table starts with 1

'For i = 3 To FREEROW - 1'


'Next i'

Call AddPrimaryKey

'Call ImportProjectFromDataBase'

MsgBox "New added"

End Sub

Sub ImportProjectFromDataBase()
Dim n As Integer
Dim i As Integer
Dim ws1 As Worksheet: Set ws1 = ThisWorkbook.Sheets("PivotDataSummarry")
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("DataSummarry")
Dim oRange As Range

'Speed Up'
Application.ScreenUpdating = False
Application.EnableEvents = False

'DeleteCodes'
ws1.Columns(1).ClearContents

'refresh pivot table'
Dim pt As PivotTable
Set pt = ws1.PivotTables("PivotTableSummmaryOfMasterData")
pt.RefreshTable
'Lastrow'

Dim LASTROW As Long

LASTROW = ws1.Range("B65536").End(xlUp).Row

Dim LASTROW2 As Long

'Get codes'

Dim Targ As Variant

For i = 3 To LASTROW

    Targ = ws1.Cells(i, 2).Value

    Set oRange = Sheets("DataBase").Columns("B").FIND(what:=Targ,
    LookIn:=xlValues, 
    lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, 
    MatchCase:=False, SearchFormat:=False)

If oRange Is Nothing Then
MsgBox "error finding project code from DataBase"

Exit For

End If

ws1.Cells(i, 1).Value = oRange.Offset(0, -1).Value

Next i

LASTROW2 = ws2.Range("B65536").End(xlUp).Row

ws2.Rows(3 & ":" & LASTROW2 + 4).EntireRow.Delete

'insert and Copy rows'

ws2.Rows(3 & ":" & LASTROW + 4).EntireRow.Insert

For i = 3 To LASTROW

    For n = 1 To 17
    Next n

Next n
Next i

'return to normal speed'
Application.ScreenUpdating = True
Application.Calculation = xlCalculationAuto
Application.EnableEvents = True

End Sub

Public Sub AddNewUpdate()

'ei toimi'

Call Add_New

'Lopeta jos cancel'
Call ExportProjectToDataBase
'Call ImportProjectFromDataBase'

End Sub
Sub ImportProjectToYearly()

Dim n As Integer
Dim i As Integer
Dim ws1 As Worksheet: Set ws1 = ThisWorkbook.Sheets("PivotDataYearly")
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("DataYearly")
Dim oRange As Range
Dim LASTROW2 As Long
Dim LASTROW As Long
Dim pt As PivotTable
Dim Targ As Variant

'Speed Up'
Application.ScreenUpdating = False
Application.EnableEvents = False

'Delete Old Codes'
ws1.Columns(1).ClearContents

'refresh pivot table'

Set pt = ws1.PivotTables("PivotTableYearlySummary")
pt.RefreshTable

'Lastrow in yearly pivot'

LASTROW = ws1.Range("B65536").End(xlUp).Row

'Get codes'

For i = 3 To LASTROW

    Targ = ws1.Cells(i, 2).Value

If oRange Is Nothing Then
    MsgBox "error finding project code from DataBase"
    Exit For
End If

ws1.Cells(i, 1).Value = oRange.Offset(0, -1).Value

Next i

'Delete all old data form yearly data'

LASTROW2 = ws2.Range("B65536").End(xlUp).Row

ws2.Rows(3 & ":" & LASTROW2).EntireRow.Delete

'insert and Copy rows'

ws2.Rows(3 & ":" & LASTROW).EntireRow.Insert
For i = 3 To LASTROW

    For n = 1 To 17
    Next n

Next i

'return to normal speed'

Application.ScreenUpdating = True

Application.Calculation = xlCalculationAuto

Application.EnableEvents = True

End Sub

Public Sub UpdateModel()

    Call AddPrimaryKey

    Call ImportProjectToYearly

    ActiveWorkbook.Model.Refresh

End Sub
MsgBox "Updated"

End Sub

Public Sub AddPrimaryKey()

'Updates RowNumber so that first row in table starts with 1
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("DataBase")

Dim LASTROW As Long
LASTROW = ws2.Cells(Rows.Count, 1).End(xlUp).Row

For i = 3 To LASTROW
Next i

End Sub
Public Sub ExportProjectToDataBaseWithInput(Targ As Variant)

'with project code'

If Targ = "" Then
    MsgBox "no code given, database not updated"
    Exit Sub
End If

Dim ws1 As Worksheet: Set ws1 = ThisWorkbook.Sheets("DataYearly")
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("DataBase")

Dim iRet As Integer
Dim strPrompt As String
Dim strTitle As String

Dim firstAddress As Variant
Dim oRange As Range
'Test if there is already project with same code in pivot table'

Set oRange = ws2.Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
MatchCase:=False, SearchFormat:=False)

If Not oRange Is Nothing Then

' Promt
strPrompt = "Already exists in DataBase. Overwrite Data?"

' Dialog's Title
strTitle = "My Tite"

iRet = MsgBox(strPrompt, vbYesNo, strTitle)

' Check pressed button
If iRet = vbNo Then
    Exit Sub
Else

'delete data from database'

Do

    Set oRange = Sheets("DataBase").Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
        lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
        MatchCase:=False, SearchFormat:=False)

    If Not oRange Is Nothing Then
        oRange.EntireRow.Delete
    End If

Loop While Not oRange Is Nothing

End If
End If

Dim LASTROW As Long
LASTROW = ws2.Cells(Rows.Count, 1).End(xlUp).Row

Dim FREEROW As Long
FREEROW = LASTROW + 1

Dim Code As Variant
Dim Name As Variant

Dim Year As Long
Dim sDate As Date

Dim BCE As Double
Dim ICTCE As Double
Dim BOE As Double

Dim ICTOE As Double

Dim BFE As Double

Dim ICTFE As Double

'does it exist in Yearly? if so; saves the location to oRange'
Set oRange = ws1.Columns("A").FIND(what:=Targ, LookIn:=xlValues, _
    lookat:=xlWhole, SearchOrder:=xlByRows, SearchDirection:=xlNext, _
    MatchCase:=False, SearchFormat:=False)

If oRange Is Nothing Then
    MsgBox "error dose not exist"
    Exit Sub
End If

firstAddress = oRange.Address

Do
Code = oRange.Value

Name = oRange.Offset(0, 1).Value

Year = oRange.Offset(0, 2).Value

BCE = oRange.Offset(0, 3).Value

ICTCE = oRange.Offset(0, 5).Value

BOE = oRange.Offset(0, 7).Value

ICTOE = oRange.Offset(0, 9).Value

BFE = oRange.Offset(0, 11).Value

ICTFE = oRange.Offset(0, 13).Value

sDate = DateValue("1/1/" & Year) 'Ei toimi surfacen officessa 1.1. muodossa???'

ws2.Rows(FREEROW & ":" & FREEROW + 11).EntireRow.Insert

Dim i As Integer
For $i = 0$ To 11

ws2.Range("A" & FREEROW + i).Value = Code

ws2.Range("B" & FREEROW + i).Value = Name

ws2.Range("C" & FREEROW + i).Value = DateAdd("m", i, sDate)

ws2.Range("D" & FREEROW + i).Value = BCE / 12

ws2.Range("F" & FREEROW + i).Value = ICTCE / 12

ws2.Range("H" & FREEROW + i).Value = BOE / 12

ws2.Range("J" & FREEROW + i).Value = ICTOE / 12

ws2.Range("L" & FREEROW + i).Value = BFE / 12

ws2.Range("N" & FREEROW + i).Value = ICTFE / 12


Next i

FREEROW = FREEROW + 12
Set oRange = ws1.Columns("A").FindNext(oRange)
Loop While Not oRange Is Nothing And oRange.Address <> firstAddress

' Updates RowNumber so that first row in table starts with 1
' For i = 3 To FREEROW - 1'
' Next i'

Call AddPrimaryKey

' Call ImportProjectFromDataBase'

MsgBox "New added"

End Sub
6.7 User form code:

Private Sub Cancel_Click()

UserForm1.Hide
Unload UserForm1

End Sub

Private Sub CommandButton1_Click()

Dim ws1 As Worksheet: Set ws1 = ThisWorkbook.Sheets("DataYearly")
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("ProjectTags")

Dim Code As Variant
Dim Name As Variant

Dim FirstYear As Long
Dim LastYear As Long

Dim BCE As Double
Dim ICTCE As Double
Dim BOE As Double
Dim ICTOE As Double
Dim BFE As Double
Dim ICTFE As Double

Code = CodeBox.Text
Name = NameBox.Text

FirstYear = StartBox.Value
LastYear = EndBox.Value

If Not IsNumeric(BCapex.Value) Then
'BCapex.Value is not a number
    BCE = 0
Else
    BCE = BCapex.Value
End If

MsgBox (BCapex.Value)
MsgBox (BCE)
If Not IsNumeric(ICTCapex.Value) Then
    ICTCE = 0
Else
    ICTCE = ICTCapex.Value
End If
MsgBox (ICTCapex.Value)
MsgBox (ICTCE)

If Not IsNumeric(BOpex.Value) Then
    BOE = 0
Else
    BOE = BOpex.Value
End If
MsgBox (BOpex.Value)
MsgBox (BOE)

If Not IsNumeric(ICTOpex.Value) Then
    ICTOE = 0
Else
    ICTOE = ICTOpex.Value
End If
MsgBox (ICTOpex.Value)

MsgBox (ICTOE)

If Not IsNumeric(BFTE.Value) Then
    BFE = 0
Else
    BFE = BFTE.Value
End If

If Not IsNumeric(ICTFTE.Value) Then
    ICTFE = 0
Else
    ICTFE = ICTFTE.Value
End If

Dim YEARS As Long

YEARS = LastYear - FirstYear + 1

Dim LASTROW As Long

LASTROW = ws1.Cells(Rows.Count, 1).End(xlUp).Row
'Last used row'

Dim FREEROW As Long

FREEROW = LASTROW + 1

Rows(FREEROW & ":" & FREEROW + YEARS - 1).EntireRow.Insert

Dim i As Integer

For i = 0 To YEARS - 1

ws1.Range("A" & FREEROW + i).Value = Code
ws1.Range("B" & FREEROW + i).Value = Name
ws1.Range("C" & FREEROW + i).Value = FirstYear + i
ws1.Range("D" & FREEROW + i).Value = BCE / YEARS
ws1.Range("F" & FREEROW + i).Value = ICTCE / YEARS
ws1.Range("H" & FREEROW + i).Value = BOE / YEARS
ws1.Range("J" & FREEROW + i).Value = ICTOE / YEARS

ws1.Range("L" & FREEROW + i).Value = BFE / YEARS

ws1.Range("N" & FREEROW + i).Value = ICTFE / YEARS

Next i

'New Tag'

Dim LASTROW2 As Long

LASTROW2 = ws2.Cells(Rows.Count, 1).End(xlUp).Row
ws2.Rows(LASTROW2 + 1). EntireRow.Insert

ws2.Range("A" & LASTROW2 + 1).Value = Code

ws2.Range("B" & LASTROW2 + 1).Value = Name

Call ExportProjectToDataBaseWithInput(Code)

UserForm1.Hide

Unload UserForm1

End Sub
Private Sub Move_cmdButton()

With ActiveSheet.Shapes("CommandButton1")
    .Top = Range(.TopLeftCell.Address).Offset(12, 0).Top
End With

ActiveWindow.ScrollRow = ActiveWindow.ScrollRow + 12

End Sub

6.8 Command button code:
Private Sub Cancel_Click()

UserForm1.Hide
UnLoad UserForm1

End Sub

Private Sub CommandButton1_Click()
Dim ws1 As Worksheet: Set ws1 = ThisWorkbook.Sheets("DataYearly")
Dim ws2 As Worksheet: Set ws2 = ThisWorkbook.Sheets("ProjectTags")

Dim Code As Variant
Dim Name As Variant

Dim FirstYear As Long
Dim LastYear As Long

Dim BCE As Double
Dim ICTCE As Double

Dim BOE As Double
Dim ICTOE As Double

Dim BFE As Double
Dim ICTFE As Double

Code = CodeBox.Text
Name = NameBox.Text
FirstYear = StartBox.Value
LastYear = EndBox.Value

If Not IsNumeric(BCapex.Value) Then
'BCapex.Value is not a number
    BCE = 0
Else
    BCE = BCapex.Value
End If
MsgBox (BCapex.Value)
MsgBox (BCE)

If Not IsNumeric(ICTCapex.Value) Then
    ICTCE = 0
Else
    ICTCE = ICTCapex.Value
End If
MsgBox (ICTCapex.Value)
MsgBox (ICTCE)

If Not IsNumeric(BOpex.Value) Then
    BOE = 0
Else

BOE = BOpex.Value

End If

MsgBox (BOpex.Value)

MsgBox (BOE)

If Not IsNumeric(ICTOpex.Value) Then

ICTOE = 0

Else

ICTOE = ICTOpex.Value

End If

MsgBox (ICTOpex.Value)

MsgBox (ICTOE)

If Not IsNumeric(BFTE.Value) Then

BFE = 0

Else

BFE = BFTE.Value

End If

If Not IsNumeric(ICTFTE.Value) Then
ICTFE = 0

Else

ICTFE = ICTFTE.Value

End If

Dim YEARS As Long

YEARS = LastYear - FirstYear + 1

Dim LASTROW As Long

LASTROW = ws1.Cells(Rows.Count, 1).End(xlUp).Row

'Last used row'

Dim FREEROW As Long

FREEROW = LASTROW + 1

Rows(FREEROW & ":" & FREEROW + YEARS - 1).EntireRow.Insert

Dim i As Integer
For i = 0 To YEARS - 1

    ws1.Range("A" & FREEROW + i).Value = Code
    ws1.Range("B" & FREEROW + i).Value = Name
    ws1.Range("C" & FREEROW + i).Value = FirstYear + i
    ws1.Range("D" & FREEROW + i).Value = BCE / YEARS
    ws1.Range("F" & FREEROW + i).Value = ICTCE / YEARS
    ws1.Range("H" & FREEROW + i).Value = BOE / YEARS
    ws1.Range("J" & FREEROW + i).Value = ICTOE / YEARS
    ws1.Range("L" & FREEROW + i).Value = BFE / YEARS
    ws1.Range("N" & FREEROW + i).Value = ICTFE / YEARS

Next i

'New Tag'

Dim LASTROW2 As Long
LASTROW2 = ws2.Cells(Rows.Count, 1).End(xlUp).Row
ws2.Rows(LASTROW2 + 1).EntireRow.Insert

ws2.Range("A" & LASTROW2 + 1).Value = Code
ws2.Range("B" & LASTROW2 + 1).Value = Name

Call ExportProjectToDataBaseWithInput(Code)

UserForm1.Hide
Unload UserForm1
End Sub

Private Sub Move_cmdButton()

With ActiveSheet.Shapes("CommandButton1")
 .Top = Range(.TopLeftCell.Address).Offset(12, 0).Top
End With
ActiveWindow.ScrollRow = ActiveWindow.ScrollRow + 12
End Sub

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