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EVENT AND DATA SOURCES FOR ENTERPRISE ARCHITECTURE DOCUMENTATION

by

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Abstract

Enterprise Architecture Management (EAM) has become a widely accepted discipline that concerns itself with the alignment of business and information technology (IT) and deals with the increasing complexity of information system (IS) landscapes. It is the practice of documenting the interrelations of business and IT entities by developing a model of the enterprise architecture (EA). This documentation of the EA acts as basis for planning the future architecture and prioritizing the projects that transform the current architecture. Due to globalizing markets and the fast paced evolution of IT, organizations are forced to become agile and frequently adapt their internal architecture in order to stay competitive. Today, the majority of tasks concerning the maintenance of EA documentation are based on manual methods and are connected to huge data collection efforts. This has a negative impact on the quality and reliability of the EA documentation and therefore diminishes the benefits of EAM. The popularly utilized EA frameworks cover the process of keeping the EA documentation up-to-date only marginally. In recent literature, there has been an effort to automate the EA documentation with the use and integration of different productive IS across the company. It was identified that common IS in organizations not only hold data about the EA, but also can contain events that could be used to trigger EA documentation processes. However, only few concrete implementations of automated EA documentation are examined in research or found in practice, because organizations face several challenges when attempting to integrate IS into an automated EA documentation. This thesis identifies possible sources of EA data and EA events in the form of common IS or databases in today's enterprises. Further, the thesis develops an evaluation catalogue for potential source candidates in order to recommend a set of suitable documentation techniques for each source. A proof of concept through a case-study at a financial institution demonstrates the feasibility and applicability of the catalogue. The proposed data source selection catalogue for EA documentation supports the identification and selection of productive IS and suitable techniques in order to increase the quality of EA documentation.

Keywords

Enterprise Architecture (EA), EA Documentation, EA Maintenance, EA Data Collection, EA Data Sources, EA Change Events, EA Automation Challenges, EA Model Repository

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Abbreviations

Abbreviation	Description
EA	Enterprise Architecture
EAM	Enterprise Architecture Management
IT	Information Technology
IS	Information System
ERP	Enterprise Resource Planning
CMDB	Configuration Management Database
ITSM	Information Technology Service Management
ESB	Enterprise Service Bus
PPM	Project Portfolio Management
BI	Business Intelligence
BPM	Business Process Management
TOGAF	The Open Group Architecture Framework
FEAF	Federal Enterprise Architecture Framework
DoDAF	Department of Defence Architecture Framework

Chapter 1 – Introduction

1.1 INTRODUCTION

Rapidly evolving technology has been resulting in very large and very complex information system (IS) landscapes (Zachman 1987). The size and complexity of such IS landscapes grows with every newly added IS and as a consequence, the integration of the added IS becomes increasingly difficult (Dern 2009). Continuous change to economic and social conditions has been a constant companion for enterprises since several years (Schekkerman 2005). Thus today's IS landscapes have to evolve much faster (Keller 2007).

To address these issues of increasing complexity and more frequent change, a new field to be known as enterprise architecture (EA) was born over twenty years ago (Zachman 1987). Since then the term enterprise architecture management (EAM) was coined and the field has evolved from an IS engineering discipline to a strategic function attached to a board member of an organization (Ahlemann et al. 2012). The general consensus about the field is that an architecture about the enterprise represented in the form of a model is developed. This EA model always shows a holistic view of the enterprise or organization and contains the description of essential structures and elements (artefacts) as well as their relations with each other and their environment (Schekkerman 2006; Hanschke 2010; Lankhorst 2013; Fischer 2008).

In the light of rapidly changing market requirements, fast-paced technological innovations and increasing competition in global value chains, today's companies must be able to adapt their business propositions and core competencies quickly (Ahlemann et al. 2012; Schekkerman 2005). This also means that organizational structures and processes as well as the use of IS and their supporting infrastructure are subject to frequent change (Ahlemann et al. 2012; Keller 2007; Hanschke 2010). As a consequence, organizations are constantly adapting their EA and if not managed correctly, run into the risk of ending up with an intransparent, complex and costly EA (Ahlemann et al. 2012).

1.2 BACKGROUND

One basic function of EAM is the documentation and analysis of the as-is state of the enterprise structures (Fischer 2008). In order to fulfil the other functions of planning a target EA and identify the changes needed to transform the current state into the target architecture, the current EA is documented in a model (Ahlemann et al. 2012; Fischer 2008). This documentation of the

EA provides the basis for strategic and enterprise-wide decisions and enables insights that make it possible to identify an prioritise the needs for change (Schekkerman 2005; Lankhorst 2013). Such an EA model is normally created with a semi-formal modelling language and then usually stored in a repository (Ahlemann et al. 2012).

In order to establish the 'as-is' EA model, the modelling architects need to have adequate knowledge about the EA and the needed information about the current EA will be distributed over multiple sources inside the company (Hanschke 2010; Lankhorst 2013). Such sources normally are subject matter experts, documents in text based form or databases of productive IS (Hanschke 2010; Lankhorst 2013). For initially creating and continuously maintaining the EA model, suitable data sources have to be identified (Hanschke 2010; Ahlemann et al. 2012; Keller 2007).

Besides the use of data sources for EA documentation, it is also important to understand at how and when changes to the EA have an impact on the EA documentation und to recognize such change events (Ahlemann et al. 2012; Hanschke 2011). External events can be used to support the process of EA documentation, namely to initiate EA documentation maintenance activities more timely and to provide context information for the responsible role incorporating the change (Farwick, Schweda, et al. 2012).

Since interviewing employees or reviewing text based documentation can be very time consuming , it is of general interest, what common IS in an organization can provide in terms of EA relevant information and in which way this can be collected.

In today's organization EA data and EA events are mostly collected with manual methods (Roth et al. 2013) and in general the documentation of the EA is regarded as a very time consuming process (Farwick et al. 2013). The most prominent challenges of EA documentation are 'huge effort in data collection' and 'bad quality of EA model data' (Roth et al. 2013). Even though automated data collection methods are expected to be highly beneficial for the quality of EA documentation (Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013), only a fraction of organizations have implemented some form of automated update mechanism for their EA model (Roth et al. 2013).

Despite those points, the most-widely applied EA frameworks, such as The Open Group Architecture Framework (TheOpenGroup 2009), cover the use of EA data and event sources when developing and maintaining an EA documentation only marginally and in such a way, that it is not enough to deal with the challenges in today's organizations. (Farwick et al. 2013; Buckl & Schweda 2011).

1.3 PROBLEM STATEMENT AND PURPOSE OF THE STUDY

After developing and establishing EA products such as models and documentation in text form, organizations struggle with maintaining the quality in terms of correctness and completeness of EA artefacts. The manual collection of EA information is a very time-consuming process, which makes it a key challenge to keep EA products up to date (Kaisler et al. 2005; Roth et al. 2013; Farwick et al. 2013).

Correctness and completeness are key quality attributes of EA products and have a direct impact on other attributes such as usefulness and conformance (Niemi & Pekkola 2013). One key risk of incorrect and incomplete EA documentation is that architects and project managers are basing their decisions on wrong assumptions, which in turn can lead to non-profitable investments or unpleasant surprises during the implementation of future projects (Ahlemann et al. 2012). The resulting uselessness of the EA products entails that employees outside EA departments such as project managers or system engineers don't understand or don't use them at all (Kaisler et al. 2005; Ahlemann et al. 2012). The distribution or even the bare existence of such EA products can have a negative impact on the overall EA acceptance of stakeholders in lower and higher management (Lucke et al. 2010).

The immense size and complexity of EA models and the frequent changes in the EA are the main reasons why the maintenance process is so important for organizations (Ahlemann et al. 2012; Farwick 2012). The maintenance of the EA documentation is difficult and time consuming because in most organizations, the work is still done manually, which means EA information is collected via interviews and surveys among different departments (Farwick 2012). Several researches point out that it should be possible to find concrete examples of information systems that contain information about common EA artefacts (Buschle et al. 2011; Hauder et al. 2012; Keller 2007) and that EA documentation highly benefits from an automated collection of existing information (Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013).

Even though several EA frameworks provide methods on how to initially construct and develop an EA, all of them fall short in giving concrete advice on how to continuously maintain the EA documentation or how to automatically collect EA relevant information (Buckl & Schweda 2011; Farwick et al. 2011a; Farwick, Pasquazzo, et al. 2012). Researchers agree that organizations typically have a multitude of operative or strategic information systems and argue that it should be possible to find concrete examples of information systems that contain information about common EA artefacts (Buschle et al. 2011; Buschle et al. 2012; Hauder et al. 2012). They also agree that future work should go into identifying and evaluation those data

sources with quality attributes with the goal of further reducing manual data collection tasks necessary (Buschle et al. 2011; Buschle et al. 2012; Hauder et al. 2012).

Outlined by the above, there is a distinct gap in the literature when it comes to the maintenance of EA documentation and the identification of EA data and event sources. This thesis makes an effort to close this gap by suggesting a set of potential EA data and event source candidates and by providing a method to assess those candidates according to quality attributes and economic factors in order to select suitable EA documentation techniques.

1.4 RESEARCH QUESTION AND OBJECTIVES

The conclusion of the introduction and the problem statement lead to the following thesis statement.

The required information to create, maintain and improve the documentation of the EA can be found in common information systems of an enterprise.

In order to validate the thesis statement, the following research questions were defined. They dissect the thesis statement into five distinctive aspects.

RQ1: What is EA relevant information?

RQ2: Which common IS contain EA relevant information?

RQ3: Can EA documentation profit from EA relevant information in common IS?

RQ4: What are key performance indicators for EAM?

RQ5: In which way can the EA relevant information in common IS be used to improve the EA maintenance?

In order to answer the research questions, the following research goals have been formulated.

RG1: To identify and analyse information systems, which contain enterprise architecture relevant information.

RG2: To recommend methods for utilizing enterprise architecture relevant information from information systems.

1.5 RESEARCH STRATEGY

The chosen research approach of this thesis is based on the design science paradigm (Hevner et al. 2004). It follows the design science research cycle phases (Vaishnavi & Kuechler 2004).

1. awareness of problem
2. suggestion
3. development
4. evaluation
5. conclusion

Each of the phases considers relevant resources from literature and compares the body of knowledge to documentation, experiences and opinions from practice, which are collected with EA practitioner interviews. The evaluation of the thesis is based on a case-study in a real environment. Further details to the research strategy are described in *Chapter 3*.

1.6 SCOPE

This thesis identifies common IS with EA relevant information and describes a method for how EA data and event sources can be assessed in order to select suitable documentation techniques and utilize their containing information about the EA. Thereby the thesis attempts to enable an improved EA documentation quality with reduced documentation efforts. The suggestion and development of the thesis is based on the literature review and EA practitioner interviews, which allows constructing a generalizable solution to the mentioned problems. The proposed artefacts and their effects are evaluated based on a case-study in an organization in the Swiss financial industry.

The scope of the thesis is limited to the identification and evaluation of potential EA data and event source candidates. The thesis includes an application of the proposed artefacts in the case-study. However, the thesis does not include an actual implementation of automated data collection or describe the details of how automated data collection should be implemented.

1.7 OUTLINE OF THE STUDY

This thesis consists of five parts. In *Part I - Introduction and Background* the context of the thesis is explained, research questions and goals are defined, the generally relevant literature is reviewed, and the design of the applied research methodology is explained. In *Part II – Awareness phase* the specific literature about EA documentation is further analyzed. The insights from literature are compared, validated and completed with the results of EA practitioner interviews. The problems and challenges of EA documentation is described in more

details. *Part III – Suggestion and Development phase* several solution concepts for EA documentation are analyzed and an own solution concept is suggested. The iterative development of a data source selection catalogue for EA documentation is described and the final product is presented. *Part IV – Evaluation phase* covers the evaluation of the developed catalogue in practice. Finally *Part V – Conclusion* depicts the results of the thesis and confirms or declines the fulfilment of the research goals. *Figure 1-1* presents a graphical map of the parts and their containing chapters.

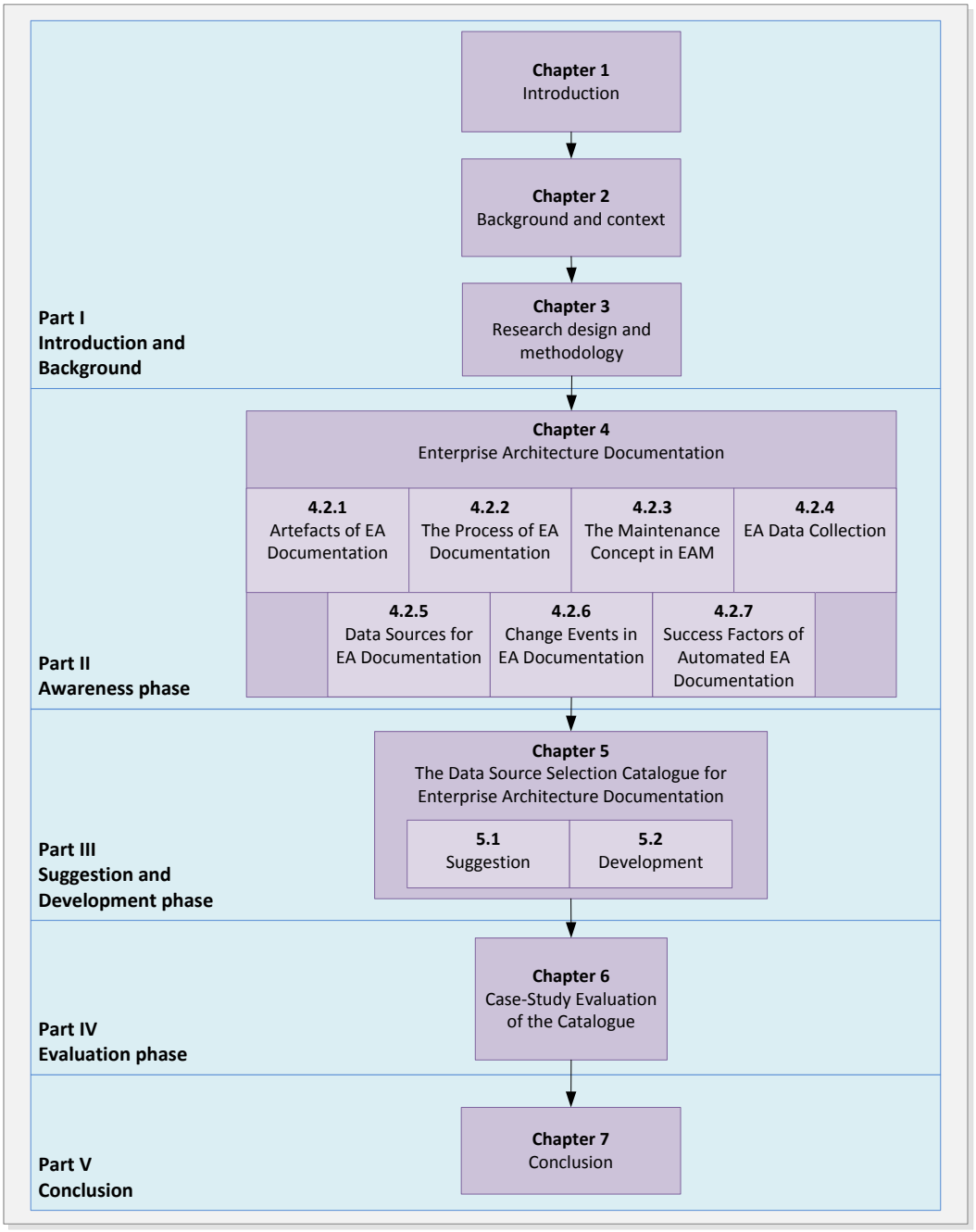

Figure 1-1: Outline of the thesis

Chapter 2 – Background and Context

The purpose of this chapter is to provide an introduction to the main topic relevant to this thesis, namely *enterprise architecture management*. After the motivation for and definitions of EAM are presented (*chapter 2.1*), the functions and representation forms of EA are examined (*chapter 2.2*). At the end, the research gap is described Enterprise Architecture Management by taking a look at the current state of EAM literature and depicting critical problems and issues in the field (*chapter2.3*).

2.1 ENTERPRISE ARCHITECTURE MANAGEMENT

2.1.1 Motivation

Since several years, the rapidly evolving technology has been removing conceptual and financial constraints, which is resulting in very large and very complex IS landscapes that allow flexibility in managing business changes (Zachman 1987). The size and complexity of such IS landscapes grows with every newly added IS and as a consequence the integration of the added IS becomes increasingly difficult (Dern 2009). The coordinated and systematic development of IS landscapes with the goals of increased stability and expandability requires managers and project leaders to possess a methodical structure of the IS landscape and have a unified long term vision (Dern 2009).

Since product cycles are shortening more and more, IS landscapes have to evolve much faster than five or ten years ago (Keller 2007). However, tightening requirements in compliance regulations and a clearly increasing sensibility for IT-Security and IT-Risks make IT projects slower rather than faster (Keller 2007).

Continuous change to economic and social conditions has been a constant companion for enterprises since several years (Schekkerman 2005). Fischer (2008) compiles a set modern developments, that raise challenges for enterprises:

- Differentiation and individualization of products as well as the globalization of development, production and distribution channels elevate the **complexity of business execution**.
- **Change** to the social and economic environment of organizations **happens faster and more frequent** due to worldwide competition.

- **Additional regulations** from legislators such as SOX, Basel II and Solvency II **tighten the requirements and standards** that enterprises have to comply with.
- Continuous advancement of technological capabilities in all business domains offers new potentials but simultaneously **increases dependency on technology** and **augments dangers of technology-related risks**.

Ahlemann et al. (2012) argues that in order to adapt business propositions and core competencies rapidly, enterprises constantly have to change their organizational structures and processes, optimize the use of there IS and strengthen their supporting infrastructure. According to them this means that enterprises are constantly changing their EA and if not managed correctly, enterprises will end up with in an intransparent, complex and costly EA that makes it increasingly difficult for the IS landscape to be flexible and fulfill business needs.

2.1.2 History

In the late 1980s, in order to develop an overall architectural vision for an organization and address aspects such as system complexity, poor business – IT alignment, cost, agility and reducing time-to-market, the concept of EAM was born (Ahlemann et al. 2012; Hanschke 2010). According to Ahlemann et al (2012) the discipline of EAM has evolved in three phases over the last 25 years:

1. EAM for IS engineering (EAM is rooted in Zachman's framework for the holistic engineering of information system)
2. EAM for IS management (Advanced EAM frameworks integrate planning, implementation and controlling processes for IT/IS landscapes)
3. EAM for strategic business management (EAM becomes a strategic function attached to a board member)

2.1.3 Definition

The term 'Enterprise Architecture' consists of the two words 'Enterprise' and 'Architecture'. An enterprise can be defined as *"any collection of organizations that has a common set of goals and/or a single bottom line"* (TheOpenGroup 2009). The word 'Architecture' is used in many contexts and can be seen as *"fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution"* (ISO/IEC/IEEE 2011).

According to Lankhorst (2013) architecture on the level of an entire enterprise is commonly referred to as 'Enterprise Architecture' (EA). Since the world has not settled on a precise

definition of EA, there are a multitude of different definitions from various institutes and frameworks (Keller 2007; Schekkerman 2005).

Lankhorst (2013) defines EA as *"a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure."* He also points out that providing a holistic view of the enterprise is the most important characteristic of the enterprise.

Schekkerman (2005) gives a more detailed definition and describes EA as *"a complete expression of the enterprise; a master plan which 'acts as a collaboration force' between aspects of business planning such as goals, visions, strategies and governance principles; aspects of business operations such as business terms, organization structures, processes and data; aspects of automation such as information systems and databases; and the enabling technological infrastructure of the business such as computers, operating systems and networks".*

Even though the various definitions for EA vary in the details, a lot of authors agree on a similar basic understanding: The EA represented in the form of a model always shows a holistic view of the enterprise or organization and contains the description of essential structures and elements (artefacts) as well as their relations with each other and their environment (Schekkerman 2006; Hanschke 2010; Lankhorst 2013; Fischer 2008).

2.1.4 Objectives of EAM

Organizations constantly have to create, change and adapt their architectures in order to meet the requirements of their environments (Ahlemann et al. 2012). EAM has the main task to steer and execute these changes in order to ensure the competitiveness of the enterprise (Fischer 2008). In order to achieve this task, Fischer (2008) describes the five main design objectives of EAM as follows.

- **Transparency** describes the explicit traceability of the relationships between different elements of an EA. It provides possibilities to analyze the EA regarding potential risks. The application of standardized functional and technical methods contributes to the creation of transparent structures.
- **Consistency** describes the pursuit of harmonized structures in and between different layers of the EA and is composed of the two objectives alignment and integration. While alignment describes the appropriate use of IT to effectively support business

strategies, goals and needs, integration describes the goal of a successful coordination and collaboration of elements of the same type such as applications.

- **Mastering complexity** describes the goal of an efficient use of IT-capabilities in an organization. Complexity in this context is often interpreted as the size and amount of elements in an EA as well as their relations between each other. EAM strives for the homogenization of redundant structures with consolidation measures or the proactive suppression of heterogenic structures with architecture principles.
- **Agility** focuses on the ability of an organization to quickly and cost-efficiently adapt its structures to unexpected changes of their environment. Not only does agility delimits itself on the immediate reaction of an organization after an unexpected change is meant, but rather the proactive support of the ability to adapt is meant.
- **Sustainability** in the context of EAM means to support the reusability of resources in order to ensure long-term efficient management of the enterprise.

2.2 FUNCTIONS OF ENTERPRISE ARCHITECTURE MANAGEMENT

According to Hanschke (Hanschke 2012), the essential contributions of EAM for strategic IT-management are categorized in three aspects.

- To provide transparency over the IS landscape in interaction with the business architecture
- To ensure the business-alignment of the IT with a common language and to relate the elements of IT with the business-architecture
- To facilitate strategic planning and steering of the IT with the proposition of target architectures and with the concrete input about the status and progress of implementations of the IT-roadmap to enable effective controlling

Fischer (2008) also summarizes three main functionalities of EAM as an instrument for strategical planning and steering.

- **Documentation and analysis of as is state of the EA:** The implementation of an EA should ensure the availability of an ever up-to-date, complete and consistent documentation of the essential artefacts and structures of the enterprise as well as their relationships between each other. This EA documentation provides the basis for strategic and enterprise-wide decisions that require information about several different layers of the organization (Schekkerman 2005). Fischer (2008) also quotes Lankhorst (Lankhorst 2013, p.7) who explains that *"the insights provided by an EA are needed on the one hand in determining the needs and priorities for change from a business perspective, and on the other hand in assessing how the company may benefit from*

technological and business innovations". Fischer (2008) further explains that the EA appears not only as a documentation instrument but also as tool for communicating a unified model of the enterprises structures and concepts.

- **Planning of target state of the EA:** Besides the documentation of the current EA, the second function of EAM is to develop the target state of the EA as well. It is important that the target state has to include all the relevant EA artefacts and their interrelations. The main challenge when developing the target architecture is the coordination of customer needs, business strategy, organization culture, operative processes and supporting technologies (Schekkerman 2005). This means that developing a target state is also largely dependent on the current EA (Fischer 2008).
- **Transformation of the as is state to the target state:** The EA eventually supports the effective and efficient implementation of the previously aforementioned supported decisions (Lankhorst 2013). Hereby EAM enables the quick and precise delamination of content for the several projects that drive the transformation of the architecture. EAM can provide concise information about the architectural changes of projects and helps to prioritize the sequencing of projects (Fischer 2008).

2.2.1 Representation of EA

It is important to distinguish between the actual EA and the model of the EA (Fischer 2008). Ahlemann et al. (2012) explain that in order to describe the actual EA, an EA model has to be created often by the means of a semi-formal modelling language such as ArchiMate (The Open Group 2012) and then usually stored in a specific database (EA repository). From here on, the model of the actual EA is called 'as-is model'. Other models that describe the target state of the EA can be developed, which help to guide the transformation of the EA (Ahlemann et al. 2012). From here on, the model of the target state EA is called 'to-be model'. Figure 2-1 illustrates the concept of actual EA, as-is model of the EA, to-be model of the EA and target state EA.

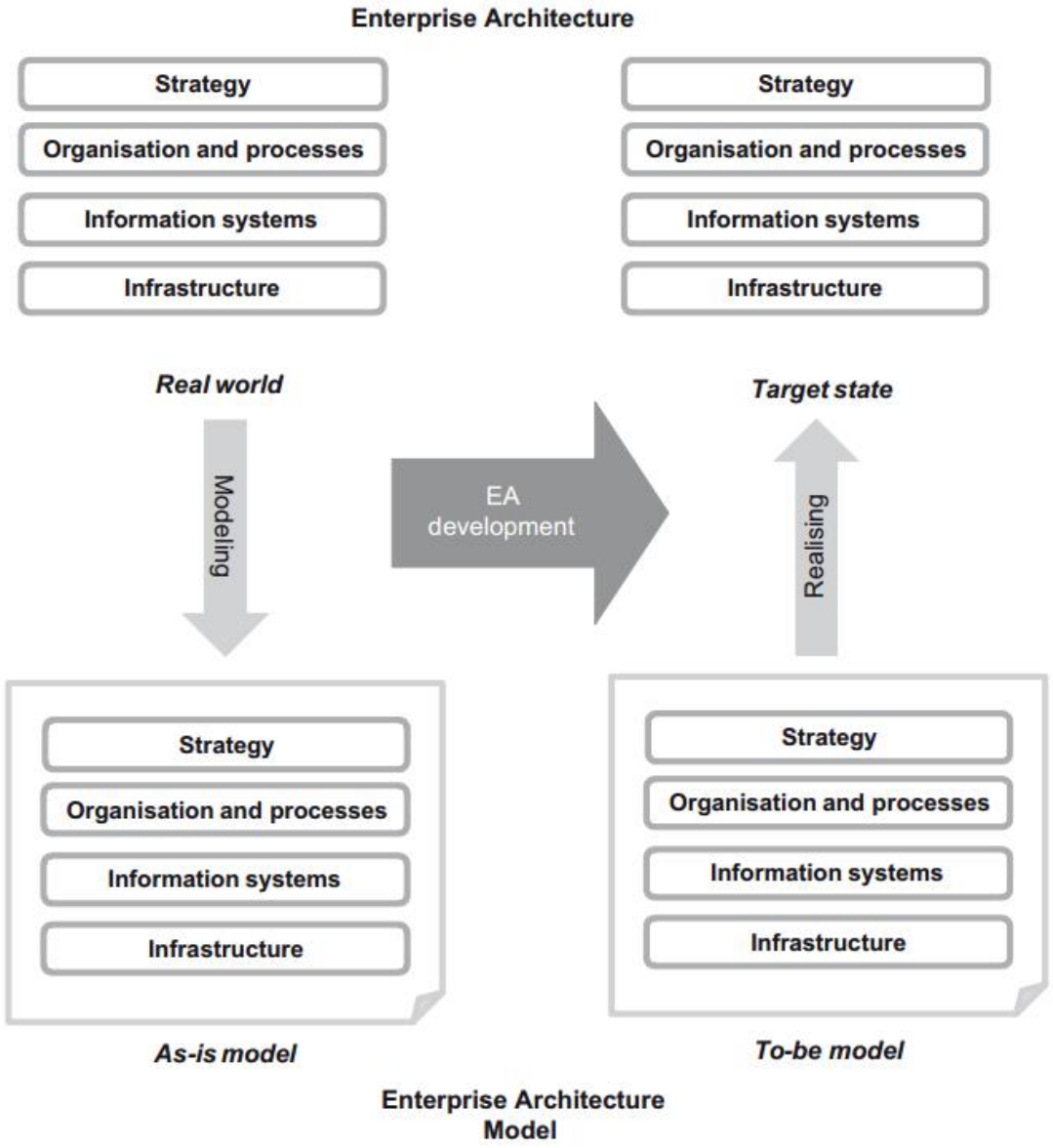

Figure 2-1: Terminology of EA and EA model (Ahlemann et al. 2012)

2.2.2 EA Frameworks

Schekkermann (2006) describes EA frameworks as a communication model for developing an enterprise architecture. He summarizes that an EA framework *"is not an architecture per se. Rather; it presents a set of models, principles, services, approaches, standards, design concepts, components, visualizations and configurations that guide the development of specific aspects architectures"* (Schekkerman 2006).

The selection of an appropriate EA framework has become a critical decision for an organization because there exist dozens of EA frameworks and the selection of one can be industry specific (Cameron & Mcmillan 2013). Cameron & Mcmillan (2013) argue that this has

to do with the fact that the architectural concepts in the majority of the frameworks are very abstract.

Schekkermann (2006) agrees with the argumentation of Cameron & Mcmillan (2013) in the point that EA frameworks generally adopt similar definitions of architecture but vary in their focus, scope, and intent and that most frameworks are developed with particular domains in mind. He also distinguishes between frameworks that focus mainly kinds of information required to document architecture and those that are more strategically oriented providing guidance on organizing evolution from current to future architectures.

According to Fischer (Fischer 2008) a typical EA framework generally covers several components, such as:

- one or multiple meta-models to describe the EA
- one or multiple methods for the creation and ongoing development of the EA
- a system of terms for the different concepts within the EA
- a reference model that acts a draft or guideline for the creation and ongoing development of the EA

Fischer points out that there are very few EA frameworks, which cover the methodological approach for the creation and ongoing development of the EA sufficiently.

Hanschke (2010) argues that almost all EA frameworks (see *chapter 2.2.2*) describe EA through various views: *"Common views are the business architecture, data architecture, application architecture and technology architecture. The links between these various sub-architectures create a complete view of business and IT structures."* (Hanschke 2010)

Winter & Fischer (2006) summarize the essential layers of EA that are found in EA frameworks as follows:

- **The business architecture** represents the fundamental organization of the corporation from a business from a business and strategy viewpoint. Common artefacts on this layer are offered services, organizational goals, and strategic project (Winter & Fischer 2006).
- **The process architecture** represents the fundamental organization of service development, service creation, and service distribution in the relevant enterprise context. Typical artefacts represented on this layer are business processes, organizational units, and informational flows (Winter & Fischer 2006).

- **The integration architecture** represents the fundamental organization of information system components in the relevant enterprise context. Typical artefacts represented on this layer are enterprise services, application clusters, integration systems and data flows(Winter & Fischer 2006) .
- **The software architecture** represents the fundamental organization of software artefacts, e.g. software services and data structures (Winter & Fischer 2006).
- **The technology architecture** represents the fundamental organization of computing / telecommunications hardware and networks (Winter & Fischer 2006).

Cameron & Mcmillan (2013) examined the use of elements from popular EA frameworks in a survey. Their results show that TOGAF (TheOpenGroup 2009) was the most frequently used framework, followed by the framework from Zachman (Zachman 1987), the Gartner framework, the FEAF and the DoDAF.

2.3 Analysis of Enterprise Architecture Literature

This chapter summarizes the results of other researches concerning the state of the art of EAM literature (*chapter 2.3.1*), critical issues and problems in EAM (*chapter 2.3.2*) and identifies a research gap in the field of EA documentation maintenance (*chapter 2.3.3*).

2.3.1 State of the Art in EAM Literature

In an effort to establish an overview over the coverage of the existing EAM frameworks and literature, Buckl & Schweda (2011) distinguished two different analysis aspects.

1. The method-centric analysis focuses on the methodical prescriptions of the frameworks.
2. The language-centric analysis is dedicated to recommendations of the language that ought to be use to model the EA.

In the method-centric analysis they further distinguish five dimensions and in the language centric analysis seven dimensions as described below. The analysis includes a wide array of EAM Frameworks and literature including the most well-known frameworks namely the Zachman Framework (Zachman 1987) and TOGAF (TheOpenGroup 2009). A summary of their results and conclusions are presented in *Table 2-1*.

Analysis aspect	Dimension	Description	Results
Method-centric	Integration	Integration EAM into other management functions such as project portfolio or strategy management	Is not addressed by one third of the approaches. Many EA management approaches seek to install EA management as a super ordinate management function instead of interrelating with other management functions.
	Develop & describe	Methods for describing current EA states and developing future EA states as well as EA principles and questions	Is well documented by majority of approaches especially for current state and architecture vision. Prescriptions for principles and questions are scarce.
	Communicate & enact	Communication of the EA states and principles to corresponding stakeholders	Is well addressed for EA states and visions but lacks prescriptions for certain artefacts such as EA roadmaps, principles and questions.
	Analyze & evaluate	Methods for analyzing and comparing different EA states	Is fairly well addressed but has the lowest coverage of the first three dimensions. Only few approaches contain methods to analyze EA target states and roadmaps.
	Configure & adapt	Mechanisms to configure and adapt a framework to organizational context and reach of the EA management function	Is not well covered overall. Particularly when concerned with tailoring and re-tailoring the methods in a changing organization.
Language-centric	Black-box perspective	Functional decomposition of the EA layers (business & organization; application & information; infrastructure & data)	Strong coverage in business and application layers but some deficits in infrastructure layer.
	White-box perspective	Structural decomposition of the EA layers elaborating on the interrelations between elements	Strong coverage of the raw make-up of an EA.
	Strategies & projects	Approaches targeting ‘projects’ as an implementer of organizational change	Covered by less than half of the approaches. This indicates that a lot of approaches do not consider the implementation of target states very well.
	Visions & goals	Approaches targeting ‘goals’ as desired ends that should be achieved	Similar to projects only covered by less than half of the approaches. This also indicates a lack of consideration for implementation of target states.
	Principles & standards	Approaches targeting ‘principles’ as delineating design constraints	Only covered by a few approaches. Mostly focusing on principles for application and infrastructure layers.
	Questions & metrics	Approaches targeting ‘questions’ as a technique to measuring success and goal achievement	Covered by about half of the approaches. Mostly focusing on metrics for application and infrastructure layers. Indicated decoupling of architecture metrics from business ones.
	Configure & adapt	Mechanisms and techniques to configure and adapt the description language of the framework	Surprisingly only covered by half the approaches as the need of an organization-specific model has been prominently addressed in literature. Particularly the need to collect not EA relevant information may stall EA endeavors early.

Table 2-1: Results and conclusions about the state-of-the-art in EAM literature (Buckl & Schweda 2011)

As can be observed, the EAM literature has a weakness in covering the 'configure & adapt' dimension in both, the method-centric and language-centric aspect. Buckl & Schweda (2011) conclude that this is a surprising outcome as most of the EAM literature preaches that companies are required to adapt any EA framework they use to their organizational structure and internal processes. Another observation that can be made is that there is a good coverage of the 'develop & describe' dimension, which should indicate well documented methods for initially acquiring EA information.

2.3.2 Critical Issues and Problems in EAM

Researchers and practitioners have encountered critical issues and problems that arise throughout the EAM process. Kaisler et al. (2005) have identified a set of challenges architects and organizations developing an EA are likely to face. They assess three key areas where critical problems are encountered, namely modeling, managing and maintaining EAs.

In the modeling area, which consists of understanding and describing the EA, the most crucial part is to select an appropriate framework and model because of the required time and effort. Once the model has been developed, it will become increasingly difficult to change it during implementation (Kaisler et al. 2005).

While developing and deploying an EA in the managing area, architects struggle with the multitude of ongoing projects, which normally operate on different timelines. They have to coordinate project schedules, resolve interface constraints between impacted IS and make sure they uphold the interoperability within their system landscape (Kaisler et al. 2005).

Since organizations continuously evolve their EA, the maintenance area is essential for preserving the operational consistency. The deployment of changes in IS should not have an impact of daily operations and the changes should be integrated into the EA. Further they make the following important observation: *"Maintaining an EA has been given little attention in the technical literature. As more EA efforts become fully engaged, we need to identify best practices in support of maintaining an deploying EAs"* (Kaisler et al. 2005)

Lucke et al. (2010) analyzed 71 articles related to EA and were able to identify five main categories, in which EA related issues occur. These categories are management, semantic problems, insufficient resources, complexity and representation. Their conclusions of EA related issues in those categories are presented in *Table 2-2*.

EA issue category	Conclusion of issues
Management	Lack of management can result in a shortfall of effective guidelines, which are crucial when it comes to collaboration of different departments in the EA process.
Semantic problems	Diverse perspectives of different domains in an organization have to be respected in the EA. Often linguistic barriers exist which create one sided influence over the EA.
Insufficient resources	Insufficient resources have an impact on the other four categories and are an issue that appears in almost every discipline.
Complexity	Due to rapidly changing conditions and often dynamic and heterogeneous environments, it is a challenge to develop and especially maintain EA models over time. A further problem can be an urge to include too much detail in an EA model, or the other extreme of oversimplifying it.
Representation	Representation issues refer to EA documentation products or deliverables and the difficulties with evaluate, utilize or appropriately communicate them.

Table 2-2: Conclusions of EA related issues (Lucke et al. 2010)

Lucke et al. (2010) point out that collaborating on and maintaining the EA are central challenges in the field due to multiple reasons. It can be argued, that the previously identified weaknesses in the configure & adapt dimension (Buckl & Schweda 2011) are also impacting those issue categories.

2.3.3 Research Gap in EA Documentation

This thesis focuses on the maintenance of EA documentation. The problem of a continuous evolution of the EA and the entailing necessary maintenance of the EA model has been identified in both research (Fischer et al. 2007; Kaisler et al. 2005; Lucke et al. 2010) and practice (Hanschke 2010). However, even though several frameworks provide methods on how to initially construct and develop an architecture, all of them fall short in giving concrete advice on how to continuously maintain the EA documentation or how to automatically collect EA relevant information (Buckl & Schweda 2011; Farwick et al. 2011a).

2.4 SUMMARY

Although the motivation, functionality and implementation of EAM are very well documented, some significant gaps regarding the maintenance of EA documentation were identified in the current state of EAM literature. While describing the creation and initial development of EA models and EA documentation thoroughly, information about how to successfully keep that documentation up to date and thereby ensuring its quality and usefulness is scarce. Recent literature (see *Chapter 4*) has discovered a lot of potential in this field and is suggesting methods to automate the EA data collection from other IS as sources, which currently is organized manually in most enterprises.

Chapter 3 – Research Design and Methodology

3.1 INTRODUCTION

In order to answer the research questions, this thesis applies a scientific research method. In the first part of this chapter this research method and its selection is described. The second part covers the application of said method in the context of the thesis. This description covers the details of each research phase and identifies the resources that are used.

3.2 DESIGN SCIENCE RESEARCH

Design science describes research by iteratively creating and assessing artefacts, which are used to solve an identified problem. The ultimate goal of design science is 'to create what is effective' (Hevner et al. 2004). It contains a set of synthetical and analytical techniques and perspectives for performing research (Vaishnavi & Kuechler 2004).

Design research in IS revolves around the creation of novel or innovative artefacts and the analysis of their use and performance. The evaluation of artefacts helps to understand, describe and improve the behavior of IS (Vaishnavi & Kuechler 2004). The artifact itself and its application in the appropriate domain have to be assessed in order to identify weaknesses and the need of further reassessment. (Hevner et al. 2004)

Hevner (2004) points out that design research is an iterative and incremental process, where the results of artifact evaluation has to incorporated in the further redesign of the artifact. Since the word design encompasses both, a product and a process, design research has two aspects, one covering the product of design and the other covering the process of design. The five phases with their outputs are illustrated in *Figure 3-1* (Vaishnavi & Kuechler 2004).

In the awareness of problem phase, multiple sources such as new developments in industry point to an interesting problem. A proposal for a new research effort represents the output of this phase. The suggestion phase includes an idea for the solution of the identified problem. It is a creative step where the combination of existing and new elements leads to tentative design. This tentative design is then further developed and implement in the development phase. The implementation in itself can be very basic since the novelty lies in the design, not in the implementation. In the evaluation phase the implemented design is then assessed with the help of requirements or criteria, which were previously defined in the proposal. In contrast to other

research methods, in design research the evaluation results in insight and knowledge, which is then fed back to another round of suggestion and restarts the cycle. This cycle can be repeated until satisfactory results have been produced, which could include deviations to originally set hypothesis and goals, science during the process new insights have been gained. These results and possible deviations are described in the conclusion phase.

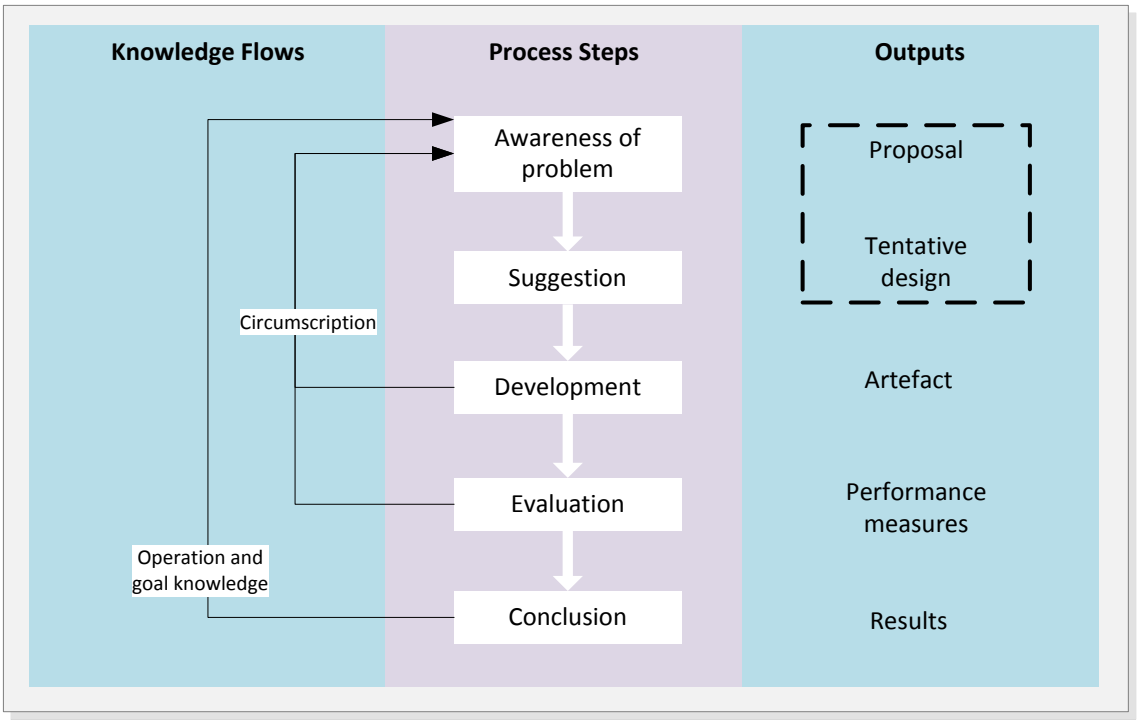

Figure 3-1: The methodology of design research (Vaishnavi & Kuechler 2004)

The conceptual framework for IS research (Hevner et al. 2004), which combines behavioral-science and design science paradigms, depicts three areas: the environment, IS research and the knowledge base. It depicts the interrelation of these areas, such that the environment and the knowledge base represent the sources for IS research, whose results are then applied in the environment respectively added to the knowledge base. Using this framework as a basis, Hevner (2007) specifies three research cycles as illustrated in *Figure 3-2*, which further describe the interrelations between the areas. The relevance cycle connects the activities in design science with the environment. This grants the research context and relevance. In the rigor cycle, the design science activities are connected to the knowledge base, providing them with scientific foundations, experience and expertise and granting the research project scientific grounding. Lastly the central design cycle iterates between the research phases as described above. This corresponds to the cycle depicted in *Figure 3-1*. Each cycle should be present and described in IS research projects (Hevner 2007).

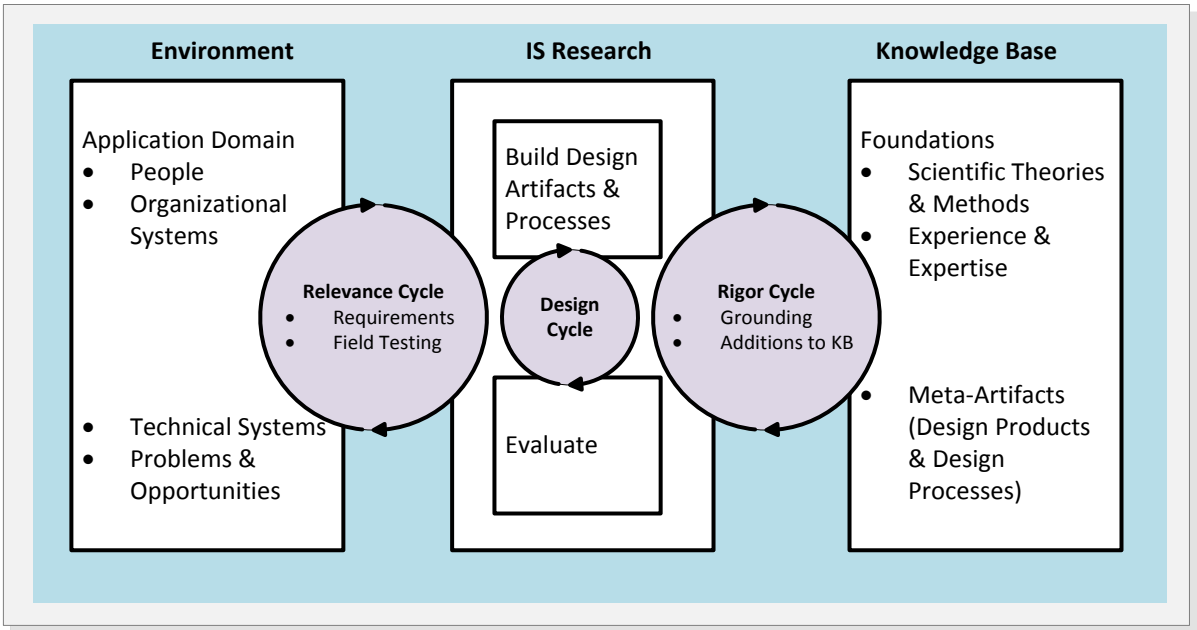

Figure 3-2: Conceptual framework for IS research with cycle view (Hevner 2007)

3.3 RESEARCH PLAN AND DESIGN

This chapter describes the specific research methodology and design that are applied in this thesis. As an overview, the research question and research objectives are given in *chapter 3.3.1*, followed by the research philosophy in *chapter 3.3.2*. *Chapter 3.3.3* explains the research strategy and *chapter 3.3.4* focuses on data collection.

3.3.1 Research question and research objectives

As described in *chapter 1.4* the research questions and research goals are the foundation of this thesis. For further reference, they are annotated with a reference and presented in *Table 3-1*.

Thesis Statement	
The required information to create, maintain and improve the documentation of the EA can be found in common information systems of an enterprise.	
Research Questions (RQ)	
RQ1	What is EA relevant information?
RQ2	Which common IS contain EA relevant information?
RQ3	Can EA documentation profit from EA relevant information in common IS?
RQ4	What are key performance indicators for EAM?
RQ5	In which way can the EA relevant information in common IS be used to improve the EA maintenance?
Research Goals (RG)	

RG1	To identify and analyze information systems, which contain enterprise architecture relevant information.
RG2	To recommend methods for utilizing enterprise architecture relevant information from information systems.

Table 3-1: Research questions and research objectives

3.3.2 Research philosophy

Myers and Avison (2002) suggest three categories based on the underlying research epistemology, which represents the assumptions about knowledge and how it can be obtained.

1. The research focus of **positivist research** is on testable propositions. Positivist research is intended to produce an exact representation of reality and relies primarily on quantitative methods (Myers & Avison 2002).
2. **Interpretive research** attempts to understand phenomena through social constructs such as language and shared meaning (Myers & Avison 2002)
3. **Critical research** also assumes that what is observed in society is socially constructed but research takes the form of deconstruction and critical analysis rather than simple interpretation (Myers & Avison 2002).

The already described research paradigm of *design science research* adds another category with its research own epistemology. Design science research by definition, changes the state of the world through the introduction of novel artefacts and can be viewed as a research philosophy of its own (Hevner et al. 2004; Vaishnavi & Kuechler 2004).

The research questions of this thesis address a problem that is encountered in the complexity of practice, and has until recently been neglected in research. The defined research goals promote the creation of artefacts, which must be evaluated and improved in order to at least partially resolve the described problem. In order to create those artefacts, multiple IS fulfilling different needs and coming from different disciplines are taken into context. These arguments support the selection of *design science research* as the applied research philosophy for this thesis.

3.3.3 Research strategy

This section describes how the design science research approach is applied. This thesis uses the iterative approach of Hevner (2004) with all three research cycles mentioned by Hevner (2007). The overview in *Figure 3-3* presents the content of the phases, indicates when research questions are answered and research goals should be achieved. It illustrates what the interrelations with the environment and the knowledge base contains. It is further indicated in which chapter which phase is by the expression ’(Ch#)’.

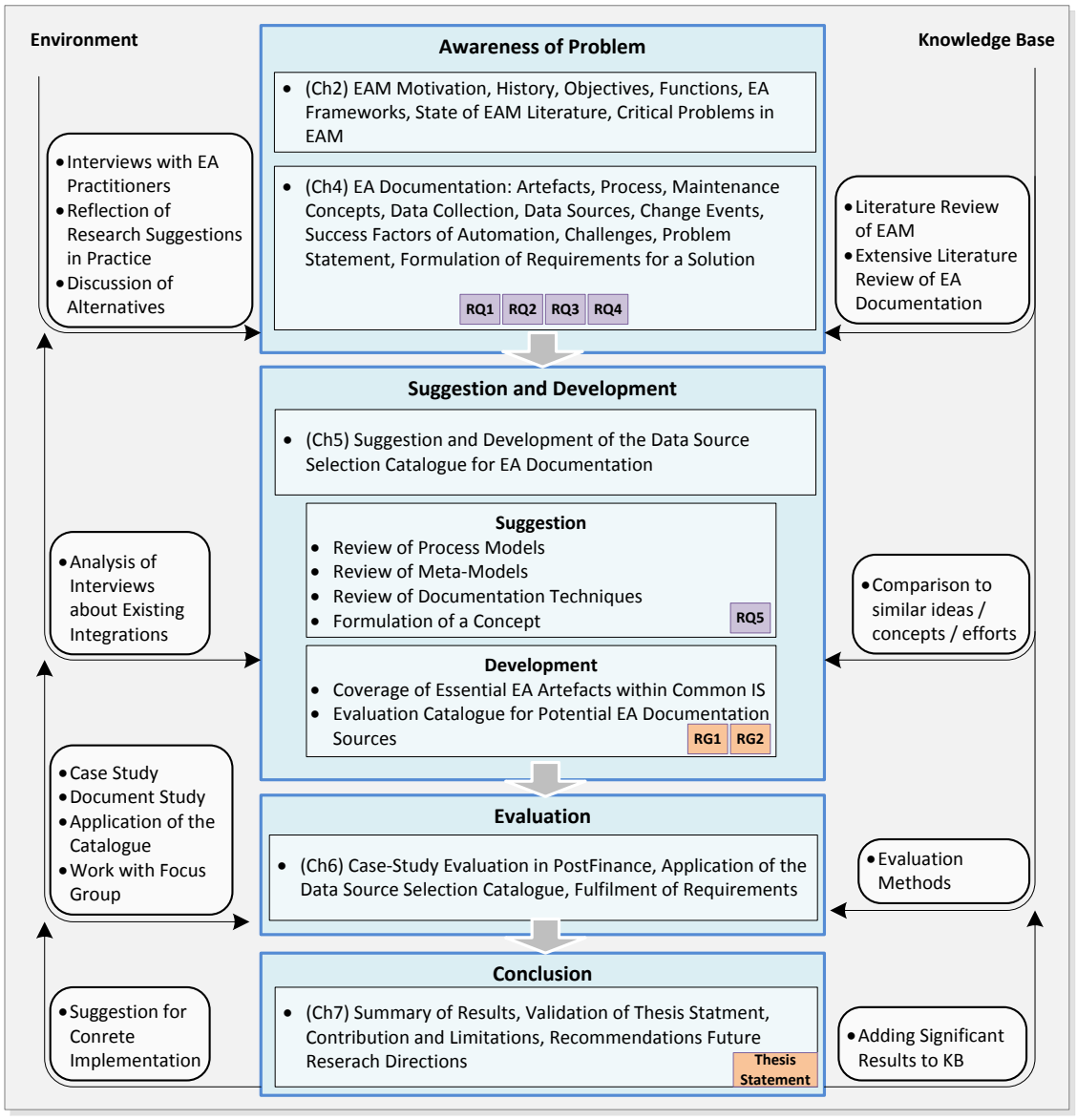

Figure 3-3: Overview of the research strategy with descriptions of the design research phases

The **awareness of problem phase** of contains a general and a specific literature review. The first general literature review is about EAM and the current state of literature (*Chapter 2*). The specific literature review is called about EA documentation (*Chapter 4*). Current practices and challenges of EA documentation are described. The insights of the specific literature review are compared, validated and completed with the results gained from interviews with EA practitioners. The chapter covers several aspects of EA documentation, including artefacts, processes, maintenance concepts, data collection, data sources, change events and success factors of automation. In the end, the insights are summarized in a problem statement and requirements for a solution are formulated. With the results of this chapter RQ1, RQ2, RQ3 and RQ4 are answered.

The **suggestion and development phase** (*Chapter 5*) analyzes concepts of current research that address the formulated problem in certain aspects. Reusable elements of those concepts are included in the suggestion of an own concept, which answers the RQ5. The concept is then iteratively developed and continuously compared to insights from research and practice. The final product is presented in details and marks the achievement of the RG1 and RG2.

In the **evaluation phase** (*Chapter 6*), the applicability and fulfilment of requirements of the newly developed artefact are tested with a case-study. At first the case is analyzed in details on the basis of informal interviews and document study. Together with a focus group of architects and subject matter experts, the developed artefact is applied to the real environment of the case-study. With the insights and results gained from the case-study and application of the artefact, the fulfilment of the previously defined requirements is described.

The **conclusion phase** (*Chapter 6*) presents the outcomes of the thesis. It demonstrates if the RQs were answered and by that, if the thesis statement can be verified or falsified. The relevant results are summarized and thereby outline the contribution and limitation of this thesis. Recommendations for practice and research topics for further efforts in the field of EA documentation are given.

3.3.4 Data collection and analysis

Primary and secondary sources of data collection are used for this thesis:

- **Literature review (secondary data):** The primary purpose of the literature review was to identify the critical issues and problems in the field of EAM and to uncover and understand the ideas, concepts and approaches that are currently being developed to address a selection of these problems. Sources included books, articles and studies from the knowledge base.
- **Interview (primary data):** In order to uncover specific characteristics of current practices in EA documentation, semi-structured interviews with subject matter experts from the environment are conducted. The form and participants of the interview are presented in *chapter 4.1*.
- **Case-study (primary data):** Outcomes and artefacts of the thesis are evaluated in the environment, where they are also applied to an existing practical setting. Details about the environment are collected with document study and unstructured interviews. A focus group of subject matter experts evaluates this implementation. With the insights and results gained from the case-study, the fulfilment of the requirements is evaluated descriptively.

3.4 SUMMARY

The methodology of design science research (Vaishnavi & Kuechler 2004; Hevner et al. 2004) is suitable research design, in order to develop a data source selection catalogue for EA documentation and to makes sure, that this developed artefact is able to tackle the described problems and to an extent, fill the identified research gap.

Chapter 4 – Enterprise Architecture Documentation in Literature and Practice

This chapter goes into a more detailed review of the literature concerning the topic of EA documentation. The chapter presents the topic from multiple angles by including relevant survey results from other publications and by gathering data from practice with EA practitioner interviews. Information about the interview method and participants are presented in *chapter 4.1*. The relevant literature is compared with the results from four EA practitioner interviews in *chapter 4.2*. To conclude the awareness phase, *chapter 4.3* summarizes the attained insights in a problem statement from which a set of requirements for possible solutions is derived.

4.1 Field Research

During this thesis, four structured interviews with EA experts have been consulted. *Table 4-1* presents details about the interview participants such as type of enterprise, industry, and job description. In three of four cases, the interview participant was the responsible person in his company for the management of the EA tool.

Participant Number	Industry Sector	Job Title	Responsible for EA tool
1	Meteorology	Data Integration Architect	yes
2	Transportation	Teamleader Enterprise Architecture Management	yes
3	IT & Logistics	Chief Architect	no
4	Insurance	Team member IT Strategy and Architecture	yes

Table 4-1: Information about interview participants

The interviews were conducted following the semi-structured interview method, which distinguishes itself from other methods by having a predefined set of questions but still allowing new ideas to be brought up or reacting to answers of the interviewee with new follow-up questions (Wengraf 2001). Each interview roughly followed the same order of question listed in *Table 4-2* and lasted from 75 to 90 minutes. The interviews were conducted in German and audio-recorded. During and after each interview, detailed notes were taken. The notes of the interviews are presented in *Appendix A*. All the interviews were conducted in person.

ID	Interview Questions
1	What kind of information is required by EAM?
2	What artefacts are produced by EAM? How is the gather information documented by EAM?

ID	Interview Questions
3	What are (possible) sources for EAM relevant information?
4	Which common IS contain EA relevant information?
5	How is EAM relevant information gathered? How are the EA and its artefacts maintained?
6	What are triggering events for updating EA artefacts?
7	What are problems / difficulties with a manual approach to data collection?
8	Are there concrete implementation of automated data collection between the EA tool and an external source? If yes: On which technology is the automation based? (XML, EXCEL, relDB, CSV, SOAP, REST) What were the reasons to build the interface? What were challenges when implementing automation? If no: Why not? Are you planning to implement automated data collection in the future? What challenges do you recognise for this?
9	How can the success of EAM be measured?
10	What influence on EAM-success does the quality of EA artefacts have?

Table 4-2: Questions used in the semi-structured interviews

4.2 INSIGHTS FROM LITERATURE AND PRACTICE

In this chapter, specific literature about EA documentation are reviewed and reflected with the testimonies from the interviewed EA experts. Each sub-chapter covers a specific topic. Important insights are summarized at the end of each sub-chapter.

4.2.1 Artefacts of EA Documentation

According to Lankhorst (2013, p.52), a main product of Enterprise Architecture Documentation is an underlying model of the total architecture. He argues that this underlying model consists of partial models from different domains and the resolved inconsistencies that appear where the partial models overlap. He further elaborates that this single underlying model is the basis for further products about the enterprise architecture, such as visualizations and impact analysis even if the model is not fully complete or consistent. This goes in line with Arbab et al. (2007), who argue that architectures are seldom defined on a single level and many different domain architectures exist inside an enterprise. They advocate that these architectures must not be viewed in isolation but rather in a coherent, integrated way.

In accordance to Lankhorst (2013) and Arbab et al.(2007), *Participant 3* argued that there are important questions that cannot be answered only with isolated specialized domain architectures. He explained that *"an aggregated holistic view over several business areas can reveal great potential for optimization"*.

Due to the range of partial models, the underlying model of an EA may consist of a huge number of artefacts (Schekkerman 2006). That is why there is an effort in EA frameworks and

EA literature to reduce the number of artefacts per model and to distinguish several architectural layers (Schekkerman 2006). For this thesis, a specific list of EA layers and artefacts has been utilized. Winter & Fischer (2006) made a consolidated analysis of EA layers and artefacts used in practice, including popular EA frameworks like TOGAF (TheOpenGroup 2009) and proposed a list of EA artefacts and layers that they consider essential for a business-oriented approach to EA. *Table 4-3* presents the list of EA layers and essential EA artefacts that is used in this thesis (Winter & Fischer 2006).

EA Layer	Description	Essential Artefacts
Business Architecture	The business architecture represents the fundamental organization of the corporation from a business strategy viewpoint.	Goals Product model Projects Core Capabilities Metrics
Process Architecture	The process architecture represents the fundamental organization of service development, service creation, and service distribution in the relevant enterprise context.	Organizational Units Organizational Roles Business Processes Business Services Business information objects Information Flows
Integration Architecture	The integration architecture represents the fundamental organization of information system components in the relevant enterprise context.	Applications Application Components IT-Services
Software Architecture	The software architecture represents the fundamental organization of software artefacts, e.g. software services and data structures	Software Components Data models
Technology Architecture	The technology architecture represents the fundamental organization of computing / telecommunications hardware and networks	Technology Components Hardware Units Network Nodes

Table 4-3: EA layers and essential artefacts that are distinguished by most EA frameworks

During the interviews the participants have been asked about what artefacts they are documenting within their EA model. Table 4-4 shows that half of the typical artefacts of Winter & Fischer (Winter & Fischer 2006) have been mentioned by the majority (three or more) of the participants. Additionally it can be seen that some additional artefacts have been mentioned but none of these by the majority of participants.

Typical Artefacts (according to Winter & Fischer)	Frequency of Mentions by Participants
Goals	*0*
Product model	2
Projects	**3**
Core Capabilities	**4**
Metrics	2
Organizational Units	2
Organizational Roles	2

Additional Mentioned Artefacts	Frequency of Mentions by Participants
Interfaces	1
Project Reasons	1
Application Clusters	2
Architecture Exceptions	2

Typical Artefacts (according to Winter & Fischer)	Frequency of Mentions by Participants
Business Processes	**3**
Business Services	2
Business information objects	**3**
Information Flows	**3**
Applications	**4**
Application Components	**3**
IT-Services	2
Software Components	1
Data models	2
Technology Components	**4**
Hardware Units	**3**
Network Nodes	2

Additional Mentioned Artefacts	Frequency of Mentions by Participants

Table 4-4: Frequency of artefact mentions by interview participants

Winter & Fischer (2006) also agree with Lankhorst (2013) in that the underlying model consist only of the most aggregate artefacts, and that more decomposed artefacts are covered in domain specific partial models. Both authors clarify that most of the artefacts are represented in the EA as aggregation hierarchies. They argue *"EA should be 'broad' rather than 'deep'"*, which means it is more useful to cover a large number of artifact types and their dependencies on an aggregate level, than to only cover a small number in much details (Winter & Fischer 2006, p.5). Hanschke (2010) also points out the importance of finding the right balance between fine granularity and abstraction and recommends not amassing excessive detail about the EA. In the understanding of Winter & Fischer (2006), EA can be defined as *"the view that represents all aggregate artefacts and their relationships across all layers"*. They point out that not only the artefacts themselves, but also the relationships between the artefacts and across the layers are considered as main components of an EA.

Participant 2 added an important statement to the question about the artefacts included in their documentation: *"You should document as few artefacts, relationships and attributes as possible, but make sure that you monitor the things that you do document. There are a lot of ideas in literature and other organizations on what artefacts could be documented. Before you add a new artifact to your EA model, always make sure that you know exactly what you will use it for and how you maintain that artifact."* This statement directly supports the arguments of the authors above (Winter & Fischer 2006; Lankhorst 2013; Hanschke 2010) that you should only document the most aggregate artefacts and avoid amassing unnecessary detail in your EA model.

The key insights of this sub-chapter are summarized in *Table 4-5*.

Key insights about artifact of EA documentation	Source
The EA consists of highly aggregated artefacts represented in a holistic model.	(Lankhorst 2013; Arbab et al. 2007)
The EA artefacts can origin from specialized architectures of the enterprise.	(Lankhorst 2013; Arbab et al. 2007)
There exist a huge number of EA artefacts, which are structured in EA layers by several frameworks.	(Schekkerman 2006; Winter & Fischer 2006)
The presented set of EA layers and EA artefacts are also represented in practice.	(Winter & Fischer 2006); *Table 4-4*
It is better to document an EA broad rather than deep.	(Lankhorst 2013; Winter & Fischer 2006; Hanschke 2010)
To document too many EA artefacts can be detrimental.	(Winter & Fischer 2006; Lankhorst 2013; Hanschke 2010); Participant 3

Table 4-5: Key insights about artefacts of EA documentation

4.2.2 The Process of EA Documentation

The process of documenting the EA encompasses the creation of an overview over the EA artefacts and their relationships (Hanschke 2010, p.130). Hanschke (2010) points out that the EA documentation is based on what information or data collections already exist in an organization and that this data has to be pulled together from various sources such as project documentation, process documentation, product and service portfolios, service management lists and so on. Hanschke (2010) further argues that creating the initial version of the documentation is a relative simple process, since once the information sources have been identified, the task can be accomplished by a few people in a short timespan (Hanschke 2010, p.131).

Once the EA documentation has been created, it needs to be maintained because Business and IT are continually changing (Lankhorst 2013; Kaisler et al. 2005). Hanschke (2010, p.131) also states that changes to the IS landscape have to be detected and the EA models must be adapted promptly. Hanschke (2010) further recommends the practices of deleting outdated aspects of the documentation or archiving of older versions.

The argument from Hanschke (2010) that initial versions of the documentation is a relative simple process depends on the desired level of completeness an organization wants to accomplish with their EA documentation. *Participant 1* pointed out that when they initially created their EA documentation, they chose to apply the '80/20 rule' (also known as the 'Pareto Principle'). He states that *"if we had the demand to document the as-is model completely, the required effort would have amounted to about two man-years".* However, he agrees with Hanschke (2010) that after the initial creation of the EA documentation, the focus immediately switches on its maintenance. *Participant 2* supported Hanschke's (2010) point of deleting outdated aspects of the documentation by stating *"We use a pragmatic step-by-step approach.*

You add a new artefact, observe how it works out, maintain the artefact, try to improve its quality and then move to the next artefact you want to add. If turns out not to be a useful artefact and you have difficulty with maintaining it, don't be afraid to remove it again instead of dragging it further along."

The development of a maintenance concept is essential in order to ensure that the EA documentation is maintained permanently (Hanschke 2010, p.131). Survey results in practice prove, that it is of central importance to have a dedicated maintenance process for the EA documentation (Aier et al. 2008). However, a majority of organizations have not defined a dedicated process for EA documentation (Farwick et al. 2013). Only *participant 4* was able to present an established process for EA maintenance. The other participants have a process for EA maintenance, which is not well defined or don't have one at all.

The key insights of this sub-chapter are summarized in *Table 4-6.*

Key insights about the process of EA documentation	Source
Creating the initial EA documentation can be time consuming, but once the sources are identified it is a relative simple process.	(Hanschke 2010); Participant 1
Maintaining the documentation is a complex and essential process.	(Hanschke 2010; Lankhorst 2013; Kaisler et al. 2005); Participant 2
Having a defined maintenance concept or a described maintenance process is key.	(Hanschke 2010); Participant 2 & 4
Defined maintenance concepts or described maintenance processes are often missing in practice.	(Hanschke 2010; Farwick et al. 2013); Participant 1-3

Table 4-6: Key insights about the process of EA documentation

4.2.3 The Maintenance Concept in EAM Approaches

There is a multitude of approaches for managing EA that have been developed by academia as well as by practitioners (Fischer et al. 2007). Fischer et al. (2007) argue that a common problem in these approaches is the lack of detail when it comes to maintenance procedures for EA models. They further point out, that while sometimes EA maintenance processes are mentioned, there is no further description of specific activities or roles. TOGAF (TheOpenGroup 2009) doesn't even mention a maintenance process and it is one of the most widely used approaches in practice.

Fischer et al. (2007) describe two fundamental differences in managing EA. On the one hand, the holistic approach encompasses a centralized EA team, which receives and interprets specific models from specialized architectures and remodels them with components from the EA meta-model (Fischer et al. 2007). On the other hand, they describe the federated approach where the existing models from specialized architectures are linked to the EA model by meta-model

integration. The federated approach is characterized by following advantages compared to the holistic approach (Fischer et al. 2007):

- less management effort (especially if the specialized models change)
- provides up to date data
- yields a higher acceptance of the resulting EA models

Fischer et al. (2007) conclude, that a federated approach is clearly better suited to address the challenge of keeping EA models consistent and up to date.

Concerning the popularity of EA management approaches, the survey results of Roth et al. (2013) show a slight favor for centralized EA teams over the mix of centralized and federated teams. The collection of EA data with an exclusively decentralized approach (only federated teams) is clearly the most unpopular choice. Aier et al. (2008) also reveal, that in practice there is distinct preference of a central maintenance approach because if a federated approach should be established, challenges of higher efforts when maintaining consistency of the decentralized gathered information arise. The survey results of Roth et al. (2013) however show a significant trend that federated teams struggle less with the collection of EA data in adequate quality.

Three of four interview participants state that they use a mix between the two approaches. A centralized EA team governs the initial creation of an artefact. For updates and general maintenance of the artefacts a federated approach is followed. Only *Participant 2* explained that since they made negative experiences with a federated approach, they are now *"[…] supervising most of their EA documentation with a centralized EA team. Only very view artefacts are maintained elsewhere. This results in higher efforts for the EA team but ensures a better quality of the EA documentation."*

The key insights of this sub-chapter are summarized in *Table 4-7.*

Key insights about maintenance concepts in EAM approaches	Source
Maintenance of EA documentation is neglected in most EAM approaches	(Fischer et al. 2007)
Between the centralized and the federated approach, the latter is better suited for maintaining the EA documentation	(Fischer et al. 2007)
In practice a purely federated approach is least represented. The majority of organizations use a mixed approach (centralized and federated).	(Roth et al. 2013; Aier et al. 2008); Participants 1-4

Table 4-7: Key insights about maintenance concepts in EAM approaches

4.2.4 EA Data Collection

Due to the nature of EA, the interconnection and accumulation of large amounts of information from various sources is required (Lankhorst 2013, p.245). Fischer et al. (2007) suggest that in order to keep the modeling efforts low, the EA model should use data from existing specialized architectures wherever possible. For each artifact in the EA model and its attributes it has to be clear who the data provider is, what triggers the data provision and via which process the data is provided (Hanschke 2010).

Farwick et al. (2013) point out that in general the documentation of EA information is a major challenge in organizations and that it is regarded as a very time consuming process. Roth et al. (2013) also included the main challenges organizations face in their survey and were able to conclude two most prominent challenges, that are 'huge effort in data collection' and 'bad quality of EA model data'. These challenges can be attributed to the fact that the most favorable method and source for EA data collection is manually from other applications and databases, closely followed by manually with interviews and manually modeled in workshops (Roth et al. 2013). Roth et al. (2013) also point out, that the least used collection method for EA data at the moment is automated collection.

These arguments are supported by the interview participants. *Participant 1* stated that to keep their as-is model as uniform and correct as possible and the majority of artefacts are maintained manually, a lot of effort is generated among their federated EA team. *Participant 3* explained that most of their maintenance efforts are currently based on manual processes, but their goal in the coming years is to implement as much automated integrations as possible to reduce EA team efforts and *"to position the EA tool as a pure slave-tool."*

Several authors agree that EA documentation highly benefits from an automated collection of existing information (Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013). Buschle et al. (2012) argue that productive information systems can be used as EA data sources. There are efforts to implement a form of automated EA documentation in some organizations, but the data collection is mostly limited to simple file import mechanisms that are manually triggered (Farwick et al. 2013). Farwick et al. (2013) also state that only few organizations consider a full integration between a productive information system and the EA tool. According to Roth et al. (2013) survey results, only 20% of respondents have implemented some form of automated update mechanism for their EA tool.

When asked about the type of automation used, *Participant 3* made it clear that they would wish that every interface to their EA tool were bidirectional and based on Web Services, but because *"[…] the corresponding information systems are productive, most of the time a simple file import based on MS Excel is the simplest and fastest way."* He further argued that the interfaces could evolve in the future and that *"most of the time it is enough to receive the data only periodically, at most on a weekly basis." Participant 2* also stated that the parts that are automated are all based on simple file imports.

Even though there is clear evidence in practice that data collection methods and processes today are not satisfactory and should be optimized (Farwick et al. 2011b), organizations still mostly rely on manual data collection (Roth et al. 2013). Additionally, two thirds of the respondents of Roth et al. (2013) survey do not have a process description for how they keep their EA up to date. This is an indication that many organizations could profit from a clearly structured process including roles and responsibilities.

But the question as to why not more organizations apply automated data collection methods persist. Multiple studies have discovered, that when it comes to integrating a data source into an automated EA maintenance process, several challenges arise (Buschle et al. 2012; Farwick et al. 2013; Hauder et al. 2012):

- The biggest challenge are the different levels of data granularity between the EA model and the data source model (Farwick et al. 2013; Hauder et al. 2012). Buschle et al. (Buschle et al. 2012) explain that the automated extraction of EA information from a data source requires a formal model transformation, which itself entails that both source and target data models are known.
- The cost of implementing an automated integration of a data source is another main obstacle (Farwick et al. 2013). Organizations also don't condone the often large investments required because they see a low return on investment in such endeavors (Hauder et al. 2012).
- As a further challenge organizations name low data quality in the data sources (Farwick et al. 2013; Hauder et al. 2012)
- Additional challenges are lack of management support, lack of standardization, problems with assigning responsibility for automatically collected data to stakeholders (Farwick et al. 2013)

Participants 2 & 4 also mentioned the different levels of granularity as their main obstacle for automated integration of data sources. *Participant 1 & 3* both mentioned the cost of

implementation is the biggest preventer of automated interfaces. *Participant 2* pointed out that it can sometimes happen that the low data quality in a source system makes automation counterproductive. In addition *Participant 1, 3 & 4* mentioned that for some information, there are no suitable data sources available. On that note, *Participant 4* clarified that sometimes even if there are data sources available, the EA team just doesn't know where to look.

The key insights of this sub-chapter are summarized in *Table 4-8.*

Key insights about EA data collection	Source
Information about EA artefacts has to be collected from different sources	(Lankhorst 2013; Fischer et al. 2007; Hanschke 2010)
Organizations in practice have two main problems with EA documentation: - huge efforts - bad quality of EA documentation	(Farwick et al. 2013; Roth et al. 2013)
EA documentation could highly benefit from automated EA data collection	(Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013)
In practice EA data is mostly collected manually. Automated methods are used rarely.	(Farwick et al. 2013; Roth et al. 2013); Participant 1 and 3
There are several challenges of automated EA data collection: - Level of granularity - Cost of implementation - Low data quality at sources - Data responsibility - Data sources are not available / unknown	(Buschle et al. 2012; Farwick et al. 2013; Hauder et al. 2012); Participant 1-4

Table 4-8: Key insights about EA data collection

4.2.5 Data Sources for EA Documentation

As previously stated, Hanschke (2010) and Lankhorst (2013) both agree, that EA documentation is built on information that is already available in different specialized architectures and can, to a certain extent, be pulled together from multiple data sources. Several authors conclude that EA documentation benefits from an automated collection of existing information from productive information systems (Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013). This leads to the question of what productive information systems can actually function as EA data sources in an organization.

Buschle et al (2011) analyzed an implemented 'Vulnerability Scanner' and discovered, that such a system can provide useful support for the creation of EA models. Further, Buschle et al (2012) found that an 'Enterprise Service Bus' contains suitable information about the EA as it coordinates interactions between applications and processes. The information gained from these operative IS primarily consists of structured applications and technology aspects (Buschle et al. 2012). This correlates with the findings of Farwick et al. (2012) that *"in most cases these data sources will provide information about the lower technical layers of the EA such as information systems and the IT-infrastructure"*. Farwick et al. (2012) add that, depending on the

organization, it should also be possible to gather information about the higher levels of EA, namely the business and process architectures. Hanschke (2010) mentions project documentation, process documentation, product and service portfolios, and service management lists but doesn't explain in details in what kind of information systems these elements can be found.

In a survey conducted by Farwick et al. (2013) participants were asked to rate different data sources concerning their importance of automatically feeding data into an EA. The set of data IS as data sources to choose from was 'Project Portfolio Management Tools', 'Configuration Management Data Base (CMDB)', 'CLOUD APIs', 'Sensors in Physical Servers (Datacenter)', 'Sensors in Application Servers', 'Existing Databases', 'Sensors in Business Process Engines' and 'Spreadsheets'. While no data source seemed unimportant, the 'CMDB' received the highest rating for importance, closely followed by 'Business Process Engines' and 'Existing Databases' (Farwick et al. 2013). The participants also named following data sources as further suggestions: 'Enterprise Service Bus Configurations', 'Monitoring Tools', 'Governance and Organization Management Tools', 'Financial Planning Systems', 'Mainframe applications' and 'Microsoft Visio' (Farwick et al. 2013).

Organizations typically have a multitude of operative or strategic information systems. Several researches point out that it should be possible to find concrete examples of information systems that contain information about common EA artefacts and also agree that future work should go into identifying those data sources and their quality attributes to further reduce the manual tasks necessary (Buschle et al. 2011; Hauder et al. 2012).

When asked what information systems contain EA relevant information and which information systems are or could be used as data sources, the most named answer by the interview participants was the CMDB followed by the ERP. The other answers are summarized in *Table 4-9*.

Information systems with relevant EA Information	Mentioned by Interview Participant #
CMDB	1, 2, 3, 4
ERP	1, 2, 4
Process Management Tool	1, 3
Project Portfolio Management Database	2, 4
HRM Tool	2, 3
ITIL-Service Mgmt Tool	2, 3

Information systems with relevant EA Information	Mentioned by Interview Participant #
Change Mgmt DB	1, 4
SOA Serice Repositories	4
Development Repositories	2
Release Management	4
BI Tools	1

Table 4-9: Information systems containing relevant EA information according to interview participants

Due to the multitude of productive IS in today's enterprises, Hauder et al. (2012) point out that the selection of the right productive information source for EA documentation is a common challenge. The possible data sources need to be assessed according to several categories that are connected to the challenges mentioned in *chapter 4.2.4*.

Three out of four candidate's state that it certainly is possible that some productive IS contain EA artefacts but that it can be hard to find a suitable data sources for two reasons:

- There is no overview available of which IS holds which data. It can be unclear of where to look.
- There are a lot of uncertainties when not analyzing the possible sources in details.

The key insights of this sub-chapter are summarized in *Table 4-10*.

Key insights about EA data sources	Source
Sources of EA artefacts can be productive IS	(Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013)
Mentioned candidates for EA data sources are the following types of IS: - ERP - HRM Tool - BI Tool - PPM Tool - BPM Tool - CMDB - Change Mgmt DB - ITIL-Service Mgmt Tool - Release Mgmt Tool - Development Repository - SOA Service Repositories - Enterprise Service Bus - Network Scanners - License Management Tool	(Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013; Farwick, Schweda, et al. 2012; Hanschke 2010; Buschle et al. 2011); Participants 1-4
Selecting EA data sources is challenging because: - Only few experiences documented - No overview of EA data sources is available - EA data sources need to be evaluated to clear uncertainties	(Buschle et al. 2011; Hauder et al. 2012); Participants 1-4

Table 4-10: Key insights about EA data sources

4.2.6 Change Events in EA Documentation

Several authors mention events and notifications that indicate changes to the EA (Ahlemann et al. 2012; Hanschke 2011; Farwick, Schweda, et al. 2012). While some only point the importance of recognizing such events (Ahlemann et al. 2012; Hanschke 2011), Farwick, Schweda, et al. (2012) argue that external events can be used to support automated EA documentation, namely to initiate EA documentation maintenance activities more timely and to provide context information for the responsible role incorporating the change. As such, external and events can have a positive impact of EA data collection processes and increase the quality of EA documentation in regards to actuality and consistency (Farwick, Schweda, et al. 2012). *Table 4-11* presents a list of IS that are used in enterprise level management disciplines and can be used to provide EA change events. The authors point out that such events don't have to originate exclusively from external IS, but can also be provided by the EA repository itself. An example would be the triggering of expiry dates on EA artefacts.

Tools with EA change events
Project Management Tools
Release Management Tools
License Management Tools
Change Management Tools
Service Management Tools
Organizational Management Tools and Directories
Enterprise Service Bus & SOA Registries
EAM Tool

Table 4-11: Data sources for EA change events (Farwick, Schweda, et al. 2012)

The 'detection of changes in the real world and their propagation to the EA model in the repository' has also been identified as a main challenge for automated EA documentation (Hauder et al. 2012). Hauder et al. (2012) explain that in order to maintain the EA repository, an automatic detection of EA changes from different information sources is required. As examples of such events, Farwick, Schweda, et al. (2012) mention new information systems, new infrustructure elements, new projects as well as changes of these elements.

All the interview participants are already intuitively using external events as triggers for EA documentation activities. Most of those events are not incorporated in an automated process, but rather tracked manually. *Participant 1* explained: *"We use an integration of the EAM process in the project life cycle. In the project initialisation there is a check on the architectural relevance of the project. At the end of the concept phase there has to be a target architecture in the EA tool defined. If this is not the case, the project is not allowed to progress into the implementation phase."* While *participant 1* explains how they make use of the project life

cycle and project gates, there is no automated detection of events from a project management tool. *Participant 2* mentions similar dependencies of other processes on the state of the EA documentation: *"The financial planning process has a finished target architecture for the corresponding period as prerequisite. Also the if a project makes a credit application, an architecture assessment of the project has to be complete."* But also hese two dependencies are manually checked. They are not using actual events from external systems but rather from their EA tool itself: *"The maturity assessement report of our domains identifies which artefacts have to be maintained. We also keep an issue tracking list from which we generate tasks. Further measures to keep a consistent EA documentation are periodic topic-oriented examinations of the EA artefact descriptions and other attributes." Participant 3* also mentions an integration into the project life cycle but without any automated use of events. *Participant 4* points out that since they also use gates in projects as triggers, they recogized that it is difficult to effectively caputer such events with the tool and that is why they used their resources to train their project managers in the usage of their EA tool. On the topic of using external EA change events to support their EA documentation efforts, *participant 4* stated: *"Yes. I could absolutely imagine that. The challenge would be to find the right events. Where do I set the pointer? One should distinguish between external events and what could be captured internally. In some IS it is defenitely possible to release a notification if a certain object changes."* In addition to this he points out that it would be especially interesting, if the EA tool then can show the user, which artefacts have changed since his last login.

The key insights of this sub-chapter are summarized in *Table 4-12.*

Key insights about change events in EA documentation	Source
Productive IS contain information about changes to the EA, that need to be recognized	(Ahlemann et al. 2012; Hanschke 2011; Farwick, Schweda, et al. 2012)
External EA change events can support automated EA documentation.	(Farwick, Schweda, et al. 2012; Hauder et al. 2012)
Events from other processes are mostly incorporated manually in practice.	Participant 1-4
The selection, detection and automated incorporation of external events is challenging and not wide spread in practice.	(Farwick, Schweda, et al. 2012; Hauder et al. 2012); Participant 4

Table 4-12: Key insights about change events in EA documentation

4.2.7 Success Factors of Automated EA Documentation

It can be difficult to measure the success of EA management quantitatively (Schekkerman 2005). In their 'EA Value Realization' model, Dietzsch et al. (2006) argue that 'realized value' is based on the users and stakeholders 'perceived/awarded value' and this in turn is based on the 'potential value' of the system and information quality. Based on the model of Dietzsch et al. (2006), Niemi & Pekkola (2013) conducted several EA practitioner interviews and identified six

quality attributes related to EA product quality, namely (1) clarity and conciseness, (2) granularity, (3) uniformity and cohesion, (4) availability, (5) correctness, (6) usefulness. Related to the attribute correctness, Niemi & Pekkola (2013) point out that EA products become erroneous, if they are not updated regularly, which has an extremely negative impact on their usefulness.

When asked about how the success of EAM can be measured and what it is based on, participant 2 stated: *"Result-orientation is extremely hard for a cross-function like EAM. At the beginning, value is generated with transparency. Central to this is the documentation of EA but also the processes, how the documentation is created, maintained and used."* Participant 4 argued in a similar way: *"One cannot simply calculate a case and quantify the success of EAM. Fact is that with a structured EA documentation you can just save a lot of time. The value will be spread across the whole enterprise. Everyone can agree that when information is neatly structured it will generate value for the organization, which sadly is hard to quantify. The same thing applies to big restructuring projects that can profit from well-defined EA documentation in good quality, but it's impossible to quantify that profit."* Participant 3 also mentioned the importance of high EA documentation quality in order to generate value with EAM, but despite this fact also added: *"[…] enterprise architects should immediately be able to generate value in the form of target models or other products that are basis for decision-making instead of being busy documenting the actual state of the EA."* Participant 1 also agreed that the success of EAM is based on the quality of the EA documentation and that EAM mainly saves time because analysis of specific management questions can be done much quicker.

Since all the interview participants agreed that the quality of EA documentation is an important factor, they were also asked specifically about how they measure the quality of their EA documentation. *Participant 4* was able to give a concrete example: *"We have evaluable modeling rules. With these rules we can make a statement about the degree of documentation of [for example] an application. These rules also generate an amount of documentation errors per application, which can be reported to management. On the other hand we check random samples of the artefacts. This process is of course limited by our team resources."* Other participants don't possess such measurable quality indicators but have other methods of measuring or assuring the quality of their EA documentation. *Participant 2* explained: *"On the one hand our enterprise architects explicitly receive time to document the EA. On the other hand the EA artefacts have to be used in several operative processes. With this method it will become clear, which artefacts don't possess the adequate and have to be actively maintained. Our experience shows that artefacts, which are integrated in operative processes, generally*

show a higher quality in comparison to artefacts that are exclusively being documented." Participant 1 also stated that they deliberately created dependencies on EA artefacts in other information systems to ensure, that they detect inconsistent artefacts immediately.

With the above statements and argumentations, one can conclude that the quality of EA documentation is a main influencing factor on the success of EAM. The goal of automated integration of data sources is to increase the increase the quality of the EA documentation and to reduce the manual effort of doing so, while keeping additional work for data providers at a minimum (Farwick et al. 2011b). In order to evaluate the success of automated EA documentation effort in general, Farwick et al. (2011b) have established a set of success evaluation criteria grouped by affected stakeholders, which are involved with an automated EA documentation method (see *Table 4-13*).

Affected Stakeholder	Success Evaluation Criteria for Automated EA Documentation
Enterprise Architects	- how much time can the automated integration save the enterprise architect in comparison to the time that would have been used to update the EA documentation with the former system
	- can the automated integration gather more information and provide a more complete picture of the architecture than the former system
Data Providers	- are data owners and data providers willing or capable of providing the needed data in a satisfactory quality
	- which and how many data sources (e.g. departments) provide interfaces to the automatically collect the data
	- to what degree can the automation process actually be integrated into the normal work processes of the data owners
	- enable 'just enough' automated maintenance and avoid 'over engineering'
	- a balance needs to be found between the creation of integration mechanisms and manual collection of data, in order not to waste resources on integration
Management	- the automated EA maintenance effort is a success if the provided data quality is raised, by this, this group can make strategic decisions based on more accurate data

Table 4-13: Success Evaluation Criteria for Automated EA Documentation (Farwick et al. 2011b)

All of the interview participants mentioned the use of automated integration to at least one data source. Most of those integrations among the participants are based on simple file imports. The participants were asked what their success factors of automated EA documentation are. What all participants agreed upon was that the automated integration had to save time comparing to a manual data collection. ***Participant 2 & 3*** stated in addition that automation makes especially sense, when the artefacts that are maintained with it have to be up-to-date. This would apply to artefacts, which are used often and often change in the real world.

The key insights of this sub-chapter are summarized in *Table 4-14.*

Key insights about success factors of automated EA documentation	Source
The success of EAM is generally difficult to measure quantitatively.	(Schekkerman 2005); Participant 1-4
The quality of the EA documentation is a main influencing factor for the success of EAM.	(Dietzsch et al. 2006; Niemi & Pekkola 2013); Participant 1-4
Automated EA documentation is then successful, when: - the EA documentation quality is increased - the automated method saves time compared to a manual method - EA artefacts that change quickly and need to be up-to-date are collected automatically	(Farwick et al. 2011b); Participant 1-4

Table 4-14: Key insights about success factors of automated EA documentation

4.3 SUMMARY

This chapter summarizes the results into a problem statement (*chapter 4.3.1*) and a set of specific requirements for possible solutions (*chapter 4.3.2*).

4.3.1 Problem Statement

The literature review points out that there is a lack of coverage of EA documentation in current frameworks. Clear evidence was shown that data collection is one of the biggest challenges of EA documentation (Farwick et al. 2013; Roth et al. 2013) and that data collection methods and processes today are not satisfactory and should be optimized (Farwick et al. 2011b; Roth et al. 2013). It was pointed out by several researches that it should be possible to find concrete examples of information systems that contain information about common EA artefacts (Buschle et al. 2011; Hauder et al. 2012; Keller 2007) and that EA documentation highly benefits from an automated collection of existing information (Farwick et al. 2013; Buschle et al. 2012; Roth et al. 2013). Multiple challenges when it comes to implementing automated collection from other data sources have been identified (Buschle et al. 2012; Farwick et al. 2013; Hauder et al. 2012) and it was defined in what ways automated collection of EA documentation should be beneficial compared to manual methods (Farwick et al. 2011).

The interview participant have confirmed the importance of EA documentation for the success of EAM, admitted that EA documentation is challenging and attested to problems with their EA data collection processes. All of them have implemented some form of automated data collection but also encountered obstacles for further implementations.

In summary, organizations struggle with the data collection aspect of EA documentation. Automated EA data collection has the potential to improve EA documentation quality and save resources in the maintenance of EA artefacts. It can be said that the experience with automated EA data collection is limited, both in research and in practice. There is scarce knowledge about which productive IS contain information about EA artefacts and EA change events. A method

for how a potential data or event sources need to be evaluated in order to be successfully integrated into an automated EA data collection process is missing.

4.3.2 Requirements for a Solution

This thesis attempts to develop a product in an effort to solve the mentioned problems in practice and close the identified research gap. For this a set of specific requirements was defined:

- The solution should include the essential EA artefacts mentioned in *chapter 4.2.1*.
- The solution should contribute to a defined EA documentation maintenance concept. (see *chapter 4.2.2*)
- The solution should be applicable in a centralized, federated or mixed EAM approach (see *chapter 4.2.3*)
- The solution should address the challenges of automated EA data collection, namely level of granularity, cost of implementation, low data quality at EA sources and data responsibility (*see chapter 4.2.4*).
- The solution should provide a set of potential EA data and event source candidates (see *chapter 4.2.5* and *chapter 0*)
- The solution should describe a method to assess potential EA data and event sources and recommend suitable EA documentation techniques (see *chapter 4.2.5* and *chapter 0)*
- The solution should consider the success factors of EA documentation (see *chapter 4.2.7*) in its recommendation of EA documentation techniques.

Chapter 5 – The Data Source Selection Catalogue for Enterprise Architecture Documentation

This chapter first elaborates on suggestions of how the identified problems could be solved. In the second part the concrete development of a solution is described.

5.1 SUGGESTION

There are several different components that could contribute to solve the identified problems. This chapter has a look at such components in literature and defines a selection of elements that can be reused in the 'data source selection catalogue for EA documentation'. *Chapter 4* identified, that a dedicated maintenance process supports the quality of EA documentation. *Chapter 5.1.1* looks at several defined process models in literature and identifies elements that can be reused from them. When considering the automated integration of external sources, several key issues where identified that have to be addressed. *Chapter 5.1.2* takes a look at a meta-model for automated EA documentation that addresses some key issues and identifies relevant elements for this thesis. It was shown that data collection itself can be organized in in different ways and accomplished with different techniques. *Chapter 5.1.3* shows a collection of such techniques that can be used in EA documentation. The selected elements from the process models, the meta-model and the documentation techniques are then woven together with further aspects that were mentioned in *Chapter 4*. The concept of a solution in the form of a data source selection catalogue for EA documentation is sketched in *chapter 5.1.4*.

5.1.1 Process models

In *chapter 4.2.2* it was established that a defined EA maintenance concept and maintenance process is of central importance for successful EA dada collection (Aier et al. 2008; Hanschke 2010). Experiences in the practical field (Farwick et al. 2013; Kaisler et al. 2005) as well as the interview results gathered by this thesis show that only a minority of enterprises have a dedicated EA maintenance process described. It can be argued, that a missing EA maintenance process description in organizations is a reason for some of the identified challenges EA documentation.

Several researches have already recommended possible process structures and roles (Fischer 2008; Farwick et al. 2011a). Fischer's (Fischer 2008) work describes the four main EAM process as a whole and explains their interrelationships with the overall strategy process and the underlying operation process. 'Architecture maintenance' is one of the four EAM processes and

has no sub-processes. Fischer (2008) explains that the process is based on a federated approach of EAM (Fischer et al. 2007) and the objective of the process is to ensure a stable actuality and consistency of the as-is model of the EA. As seen in *Figure 5-1* the process includes an activity called 'Deliver Model Date', which is describes as *"Supply of corresponding Data of an operative inventory information system or detail repository according to the accepted extent and format"* (Fischer 2008, p.182). This step is based on a data delivery contract (Hanschke 2010; Fischer et al. 2007). Further explanations of how data sources are identified or why they are selected are not mentioned.

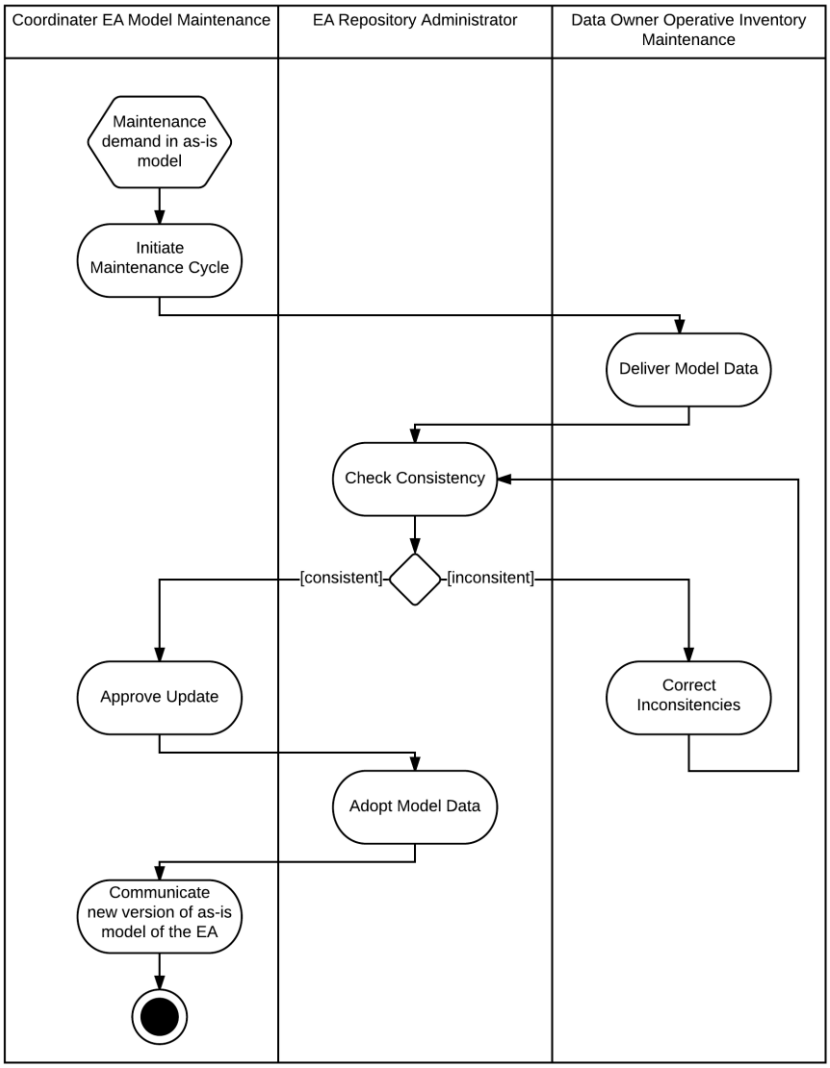

Figure 5-1: Sequence diagram of architecture maintenance process (Fischer 2008)

Farwick et al. (2011a) describe the maintenance process in more detail. In *Figure 5-2* their overview of the process is presented. Of special interest for this thesis is the sub-process '(1) Setup Process Participants' where they describe how a decision for which data source to integrate is found. Following five factors should be considered for such a decision (Farwick et al. 2011a):

1. Importance of the data for the questions that the EA effort is supposed to answer
2. Effort required for implementing an automated interface
3. Effort required for manually updating the model without automation
4. Importance of actuality of data
5. Security considerations for data exchange

When a data source has been chosen, the data owner further has to specify expiry dates of the entities that are provided and the EA repository manager should define an input mapping of the source model to the EA model (Farwick et al. 2011a). The following sub-processes like '(3) Maintenance Process' and '(4) Release Process' have strong similarities with Fischer's (2008) recommendations.

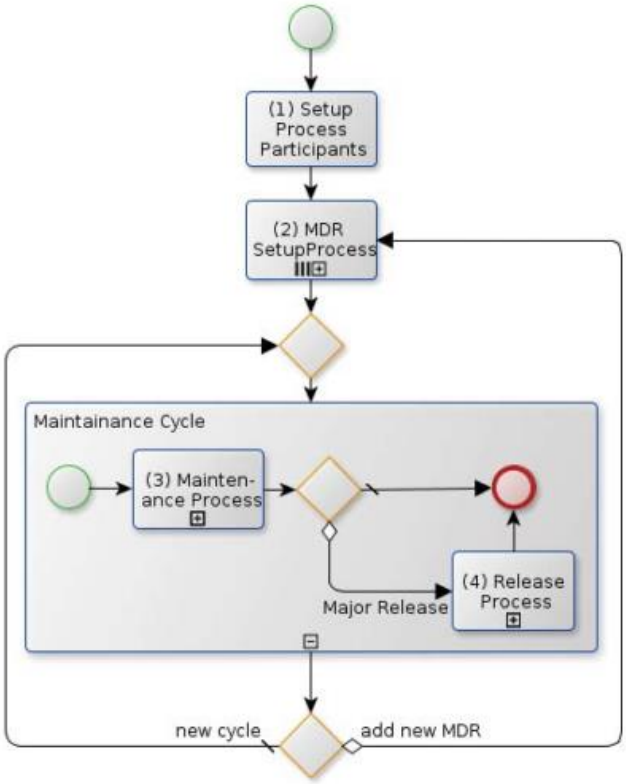

Figure 5-2: Overview of maintenance process (Farwick et al. 2011a)

This thesis can profit from the identified resources and reuses the aspects presented in *Table 5-1* for the suggestion of a concept.

Reusable aspects identified in literature about process models	Source
Supply of data of an operative IS should be defined in a data delivery contract	(Fischer 2008; Fischer et al. 2007)
Guidelines to create data delivery contract mentioned following factors to consider: - Who are providers of data? - Where is change documented? - How is change made known? - How high is the data quality at a data source? - Which data is not covered with a source yet? - Is it enough to collect an initial set of data or is it necessary to implement an automated process?	(Hanschke 2010)

Reusable aspects identified in literature about process models	Source
Factors that have to be considered when deciding on integrating a data source: 1. Importance of the data for the questions that the EA effort is supposed to answer 2. Effort required for implementing an automated interface 3. Effort required for manually updating the model without automation 4. Importance of actuality of data 5. Security considerations for data exchange	(Farwick et al. 2011a)

Table 5-1: Reusable aspects identified in literature about EA maintenance process models

5.1.2 A meta-model for automated EA documentation

Farwick, Pasquazzo, et al. (2012) developed a meta-model that augments existing EA models with necessary contextual information, which gives answers to questions such as where the data in the EA model originates from or when it needs to be updated. *Figure 5-3* shows the top layer of their meta-model, where they present that every 'ModelElementType' can originate from a 'DataSource' and is connected to 'Update' and 'Insert' elements. An instantiation of their meta-model showed that it is useful to define responsibilities to data sources and model elements and that it shows expiry events can come into play to improve an automated EA documentation.

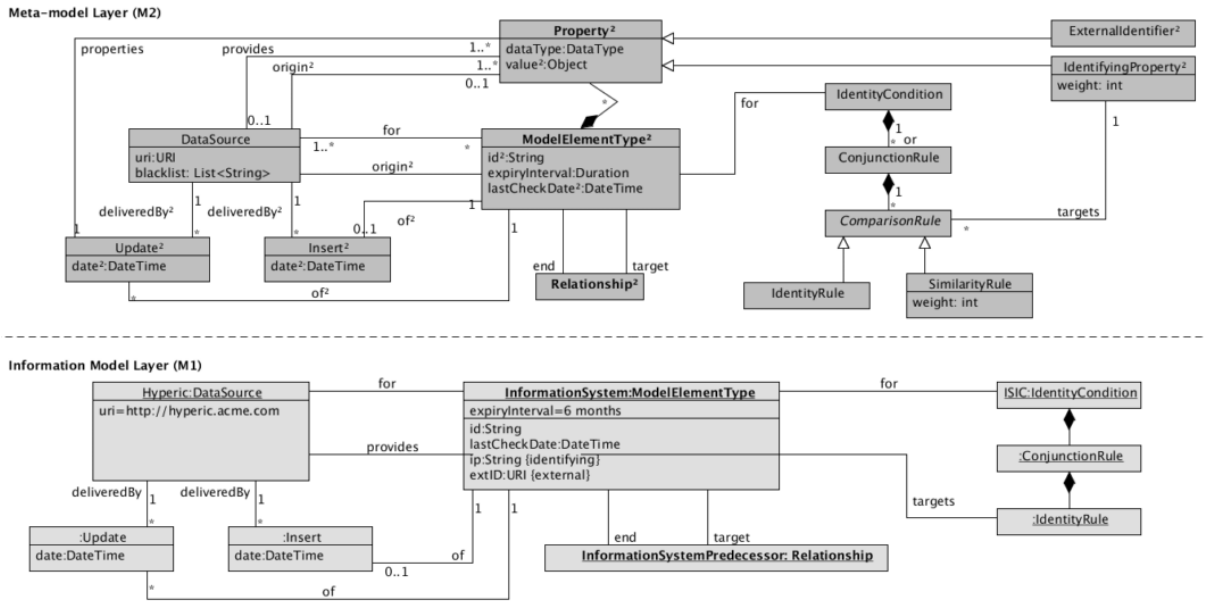

Figure 5-3: Meta-Model for automated EA model maintenance (Farwick, Pasquazzo, et al. 2012)

Table 5-2 summarizes the insights gained from the description of a meta-model for automated EA model maintenance.

Reusable aspects identified in literature about EA maintenance meta-models	Source
Each model element should have a defined data source, and expiry intervals or dates. Updates and inserts into the EA model should be kept record of. When using the EA model, it is important to know who is responsible for the element, where the data comes from, when it was updated or created and until when it will remain valid.	(Farwick, Pasquazzo, et al. 2012)

Table 5-2: Reusable aspects identified in literature about EA maintenance meta-models

5.1.3 Mixed method for EA documentation

Farwick et al.(Farwick et al. 2014) have recently argued that there is a lack in research and practice of a method for combining several EA documentation approaches in a structured way. In an effort to close this gap they define four main documentation techniques (Farwick et al. 2014) that can be used in parallel:

1. Recurring periodic manual data collection reminders for appropriate stakeholders.
2. Semi-automated data collection from external structured data sources.
3. An eventing mechanism that receives events from external information sources to initiate manual maintenance processes.
4. Internal model events for appropriate stakeholders, such as model element expiry

Beyond defining how these documentation techniques work with detailed process models, they also described a general process for the selection and assembly of those documentation techniques to form a coherent documentation method. *Figure 5-4* one displays their selection process which produces the basis for the decision of which data and event sources to integrate and which other documentation techniques to apply (Farwick et al. 2014)

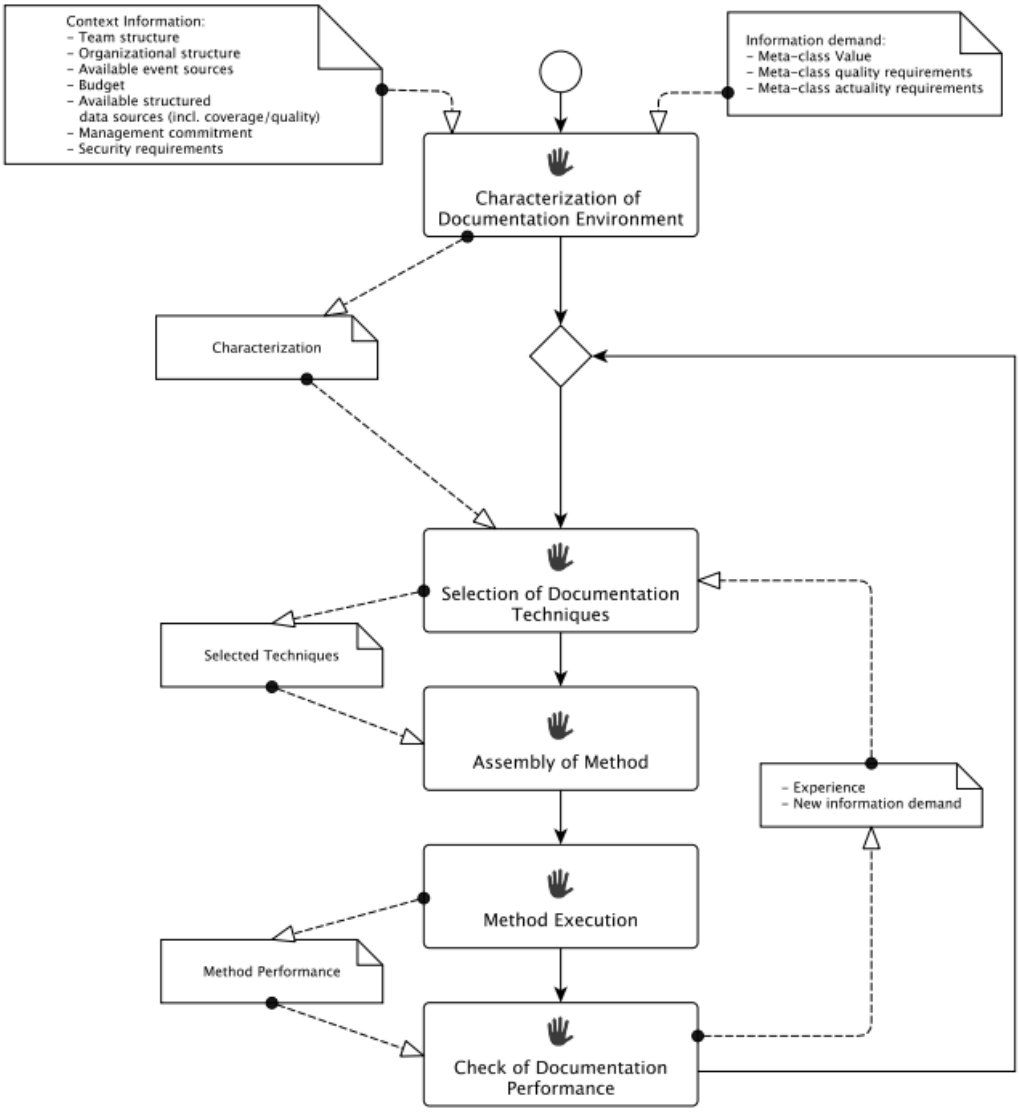

Figure 5-4: Organization specific process for the selection of appropriate EA documentation techniques

Especially the first three process activities are of interest for this thesis: 'Characterization of Documentation Environment', 'Selection of Documentation Techniques' and 'Assembly of Method'. Farwick et al. (2014) divide their approach in five steps to arrive at a decision of which documentation techniques should be used for which data source:

1. Listing of information model quality requirements (actuality, completeness, importance)
2. Listing of data sources (including type, level of granularity, available quality, information about security or performance constraints)
3. Listing of event sources (same attributes as data sources)
4. Merge in documentation techniques
5. Final ranking and decision (choose automated sources for model element types of high importance, low implementation cost and low security risk where the completeness is additionally high)

Table 5-3 summarizes the insights gained from the description of documentation techniques and their selection method.

Reusable aspects identified in literature about an EA documentation selection method	Source
There are four types of documentation techniques which holistically cover current approaches in EA documentation: 1. Periodic manual data collection 2. Semi-automated data collection 3. External events initiate manual data collection 4. Internal events initiate manual data collection	
Five step approach to support decisions about the selection of EA documentation techniques and data sources: 1. Define EA model quality requirements 2. List possible data sources with quality attributes 3. List possible sources for events 4. Assign documentation techniques 5. Rank and decide	

Table 5-3: Reusable aspects identified in literature about an EA documentation selection method

5.1.4 Concept for a data source selection catalogue for EA documentation

In order to address the problems and requirements defined in *chapter 4.3*, this thesis suggests the development of a 'data source selection catalogue for EA documentation'. This catalogue should support two major tasks in EA documentation.

1. On the one hand the catalogue presents a collection of possible data sources for automated data collection. For this, the catalogue includes the most common IS that are found in an enterprise and indicates which EA artefacts (see *chapter 4.2*) are generally available in which IS. The catalogue further presents which external events (see *chapter 0*) could be utilized from which possible data source. All this is done in a matrix that can also be adapted to an organization IS landscape and EA model. This matrix assists the EAM tasks of analyzing the IS landscape and identifying possible data sources for EA documentation. A concept for this matrix is shown in *Figure 5-5*.

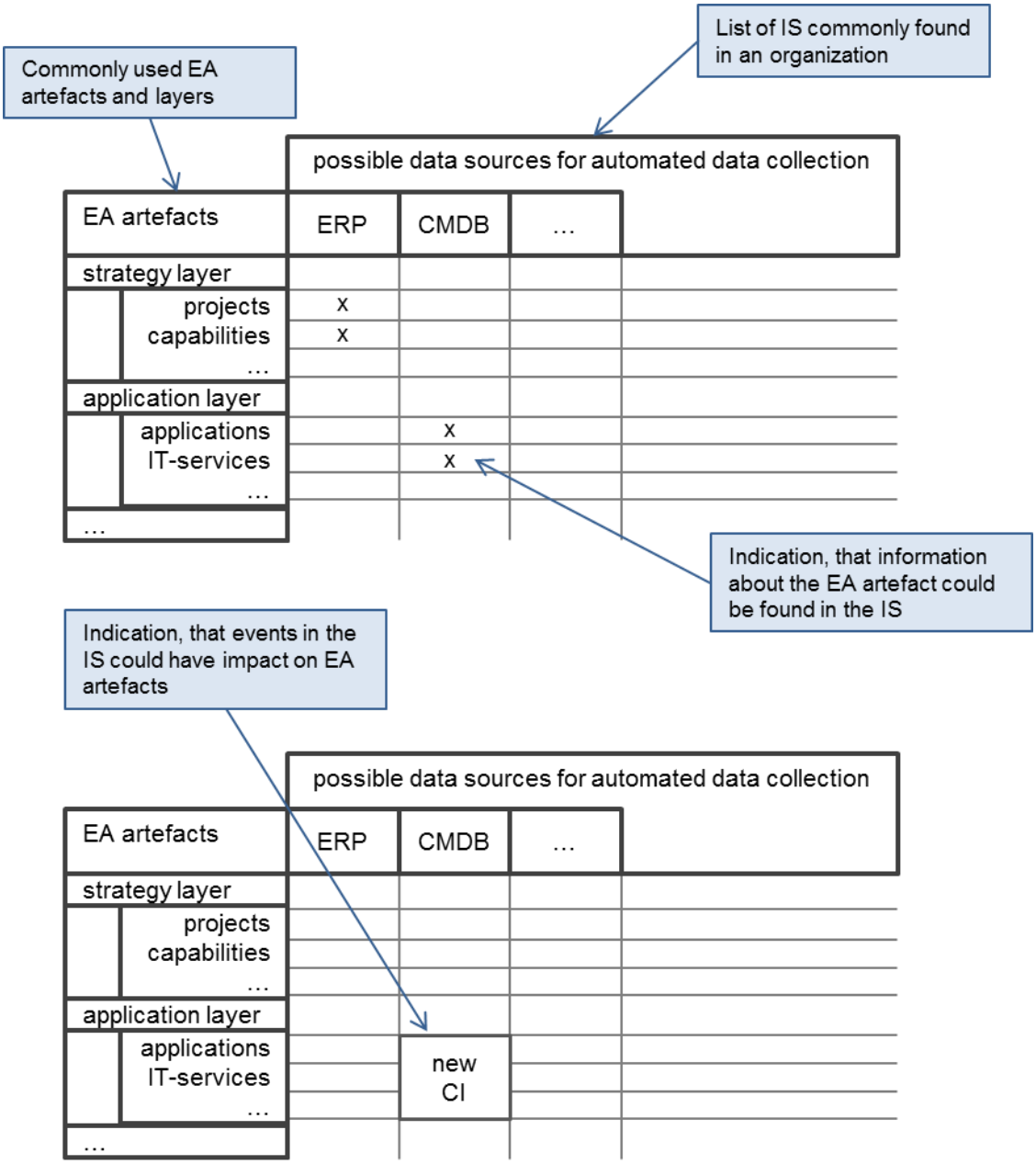

Figure 5-5: Concept for the matrix with data sources and EA artefacts

2. The catalogue provides a guided evaluation of the identified possible data sources. In order to evaluate an IS as possible data source, further organization specific effort is required. To support the evaluation, the catalogue stipulates relevant criteria and provides an exemplary rating system. Depending on the outcome of the rating process, the catalogue recommends the implementation of a suitable EA documentation technique. Thereby the EAM task of selecting IS as data sources and deciding on appropriate documentation techniques is supported. *Figure 5-6* shows a concept of such an evaluation catalogue.

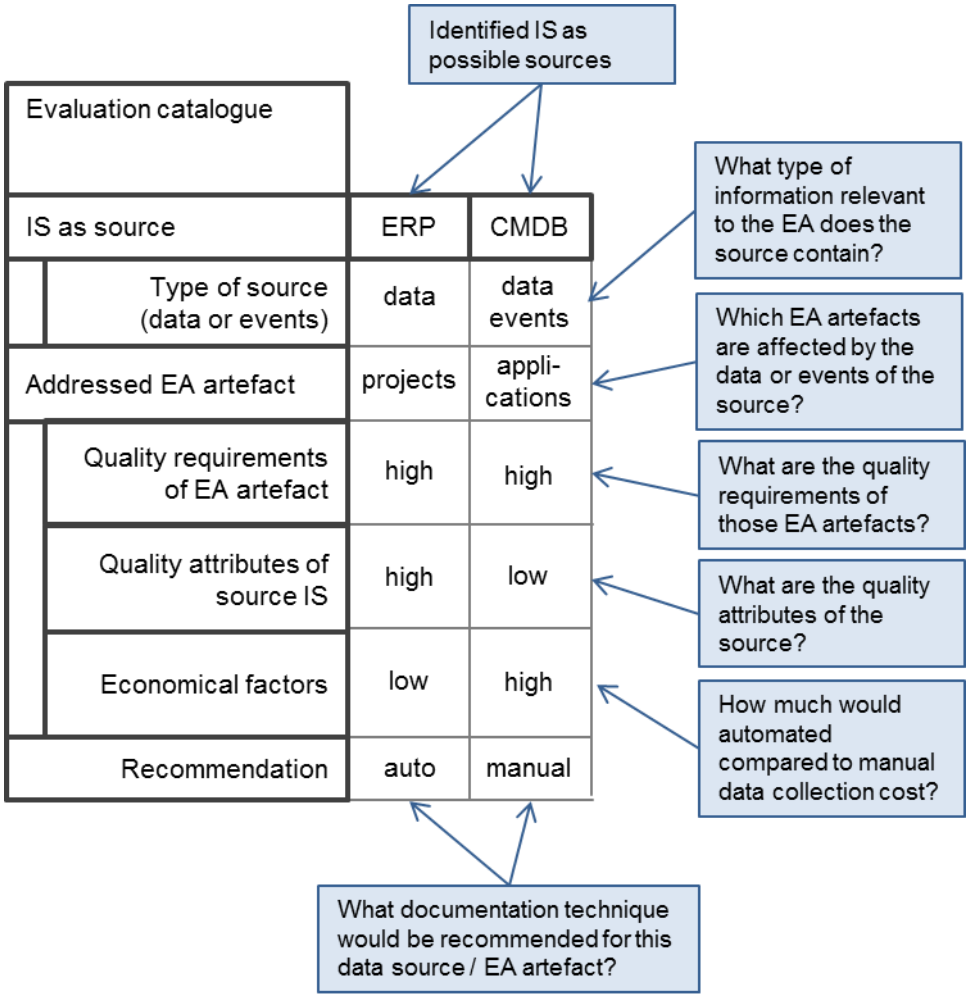

Figure 5-6: Concept for an evaluation catalogue for potential EA documentation sources

5.2 DEVELOPMENT

In this chapter the final product of the 'data source selection catalogue for EA documentation' is described in detail. It has been developed in an iterative process and was influenced from similar concepts in literature. Insights from the interview participants were considered to ensure the relevancy of the catalogue. The description includes reasoning on design decisions and provides guidance on how the catalogue should be applied in practice.

The chapter is divided in two parts. *Section 5.2.1* presents a coverage matrix of essential EA artefacts and common IS in organizations. *Section 5.2.2* covers the evaluation process of potential data sources for EA documentation.

5.2.1 Coverage of essential EA artefacts within common IS

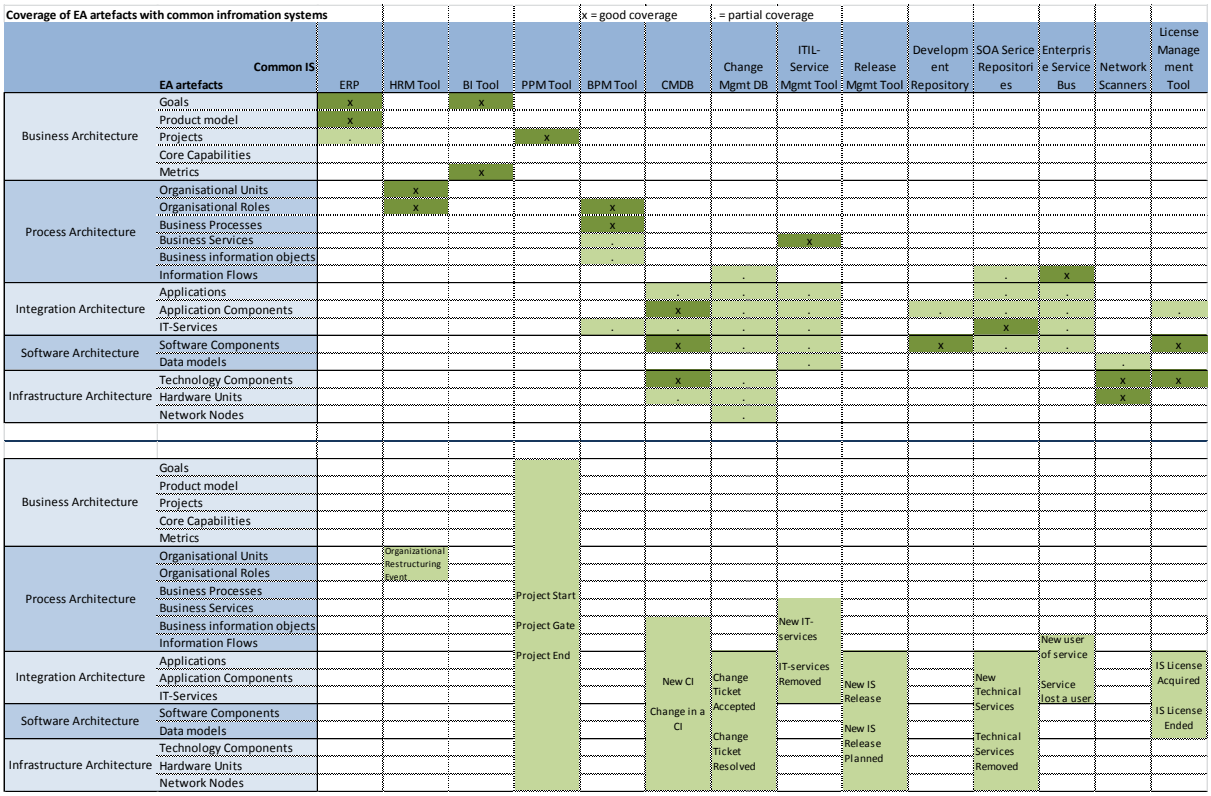

Figure 5-7: Coverage of essential EA artefacts within common information systems

Figure 5-7 represents the developed matrix that was created to analyze the coverage of essential EA artefacts within common IS of an organization. The matrix consist of a list of essential EA artefacts (rows) and a list of commonly implemented IS (columns).

5.2.1.1 List of essential EA artefacts

Business Architecture	Goals
	Product model
	Projects
	Core Capabilities
	Metrics
Process Architecture	Organisational Units
	Organisational Roles
	Business Processes
	Business Services
	Business information objects
	Information Flows
Integration Architecture	Applications
	Application Components
	IT-Services
Software Architecture	Software Components
	Data models
Infrastructure Architecture	Technology Components
	Hardware Units
	Network Nodes

Figure 5-8: List of essential EA artefacts

Chapter 4.2 established how the EA model acts like an underlying model over the whole enterprise. It consists of the most aggregate elements of multiple specialized architectures (Lankhorst 2013). These aggregates are called EA artefacts and are separated with different layers. Winter & Fischer (Winter & Fischer 2006) analyzed the most widely used EA frameworks, proposed a list of core artefacts of EA and validated their proposal in practice. This thesis challenged this list of essential EA artefacts by checking the relevance of the mentioned artefacts in practices. Comparing

the answers of the interview participants with the list concluded in a good match between literature and practice. Therefore the list of essential EA artefacts described in *Figure 5-8* was used in the rows of the matrix.

5.2.1.2 List of commonly implemented IS

Chapter 4.2.5 presented that information about EA artefacts can be found in several productive information systems in an organization. The interview results supported this argument. *Table 5-4* shows the list of commonly implemented IS in organizations, which is based on mentioned possible EA data sources in literature and practice. This list of IS is used in the columns of the matrix.

Tools with relevant EA Data	Literature Sources	Interview Participant #
ERP	(Farwick et al. 2013)	1, 2, 4
HRM Tool	(Farwick et al. 2013)	2, 3
BI Tool		1
PPM Tool	(Hanschke 2010; Farwick et al. 2013; Farwick, Schweda, et al. 2012)	2, 4
BPM Tool	(Hanschke 2010; Farwick et al. 2013)	1, 3
CMDB	(Farwick et al. 2013)	1, 2, 3, 4
Change Mgmt DB	(Farwick, Schweda, et al. 2012)	1, 4
ITIL-Service Mgmt Tool	(Hanschke 2010; Farwick, Schweda, et al. 2012)	2, 3
Release Mgmt Tool	(Farwick, Schweda, et al. 2012)	4
Development Repository		2
SOA Service Repositories	(Farwick, Schweda, et al. 2012)	4
Enterprise Service Bus	(Buschle et al. 2012; Farwick et al. 2013; Farwick, Schweda, et al. 2012)	
Network Scanners	(Buschle et al. 2011; Farwick et al. 2013)	
License Management Tool	(Farwick, Schweda, et al. 2012)	

Table 5-4: List of IS mentioned as possible EA data sources in literature and practice

5.2.1.3 Mapping of essential EA artefacts with commonly implemented IS

There are two different aspects of coverage that are highlighted. The first mapping is based on available elements in the IS that could represent an EA artefact. For example in a CMDB, in theory there exist concrete objects related to EA artefacts such as application components, software components and technological components (Farwick et al. 2013). From here on this type of mapping is called ‘data mapping’ and the IS providing the EA artefact is called ‘data source’.

During the development of the matrix in *Figure 5-7* it became evident, that a IS could cover the EA artefact only partially, and that binary mapping of ‘covered’ and ‘not covered’ could be detrimental. For this reason the matrix also incorporates a ‘partially covered’ mapping.

The second mapping is based on events in IS that affect the EA artefacts. An example for such event is could be a newly required license for a software in a license management tool that would indicate, that there needs to be an update to the EA artefact 'software component' (Farwick, Schweda, et al. 2012).From here on this type of mapping is called 'event mapping' and the IS offering such an event is called 'event source'. The matrix in *Figure 5-7* shows possible events from commonly implemented IS and maps them to artefacts that could potentially be affected.

Due to differences in IS landscapes an EA artefacts of every organization, the mappings presented in this matrix are not perfectly applicable in practice and should only be considered as starting draft mapping, on which EA efforts in an enterprise can build on. When considering automated EA data collection, the first step should be to apply this matrix to the corresponding EA and IS landscape. The predefined mappings can be deleted or modified and provide initial hints on where to look for which EA artefacts. For these reasons a detailed explanation of every mapping between essential EA artefacts and commonly implemented IS was omitted in this thesis. The complete matrix and proposed mappings is available in *Appendix B*.

5.2.2 Evaluation Catalogue for potential EA Documentation sources

	ID		[ID]
A	Source IS		[IS]
	Type of source	Data source	[x; " "]
		Event source	[x; " "]
B	Provides information EA artefact		[EA artefact]
	Quality requirements of the EA artefacts	Actuality	[Hourly; Daily; Weekly; Monthly; Yearly]
		Completness	[Whole Organization; Restrictions to Org Units, Locations; Defined Sub-Set; ...]
		Importance	[Low; Medium; High]
C	Quality attributes of the source IS	Level of Granularity	[Coarse grained; Medium Grained; Fine Grained]
		Consistency	[Low; Medium; High]
		Actuality	[Hourly; Daily; Weekly; Monthly; Yearly]
		Completness	[Whole Organization; Restrictions to Org Units, Locations; Defined Sub-Set; ...]
		Constraints	[Security; Performance; Availability; Technology]
D	Economic factors	Cost of automated collection	[Low; Medium; High]
		Cost of manual collection	[Low; Medium; High]
		Is it expected to have better data quality with automated collection	[x; " "]
E	Documentation technique	Recomended method	[automated data collection; manual data collection; use of external events; use of internal events]
		Priority	[Low; Medium; High]

Figure 5-9: Evaluation catalogue for potential EA documentation sources

Figure 5-9 illustrates the 'evaluation catalogue for potential EA documentation sources'. The goal of the evaluation catalogue is to assess if the IS that have been identified with the matrix from the previous *chapter 5.2.1* are suited for automated EA data collection or for providing external events. The catalogue guides the process of evaluation by providing step by step what has to analyzed and rated by providing five sections, each colored individually. The following chapters look at each section and give a theoretical example of how the criteria could be applied.

5.2.2.1 Section A: Type of source

	ID		[ID]	1
A	Source IS		[IS]	PPMDB
	Type of source	Data source	[x; " "]	x
		Event source	[x; " "]	x

Figure 5-10: Section A of the evaluation catalogue with example

The first section is concerned about the categorization of the previously identified potential sources. The IS that are candidates for EA data collection are distinguished between data sources and event sources. This step is done first for all the identified IS. *Figure 5-10* shows an

example, where the Project Portfolio Management Data Base (PPMDB) has been identified as a potential source for both, data and events.

5.2.2.2 Section B: Quality requirements of the EA artefact

B	Provides information EA artefact		[EA artefact]	Projects
	Quality requirements of the EA artefacts	Actuality	[Hourly; Daily; Weekly; Monthly; Yearly]	Daily
		Completness	[Whole Organization; Restrictions to Org Units, Locations; Defined Sub-Set; ...]	Only IT-Projects
		Importance	[Low; Medium; High]	Medium

Figure 5-11: Section B of the evaluation catalogue with example

Before taking a more detailed look at the identified IS, *Section B* is about analyzing the quality requirements of the concerning EA artefacts. For each IS it should be defined which essential EA artefact is affected. If one IS affects multiple EA artefacts an additional column should be added for each EA artefact. In order to later on decide on a data collection method, it is important to think about three attributes of the EA artefact: required actuality, required completeness and importance.

- Actuality: Describes the required timeliness of the EA artefact, which affects how often the EA artefact needs to be updated. The update interval can vary between artefacts in an EA depending on what they are used for. Possible values are hourly, daily, weekly, monthly or yearly. Depending on the organization, individual values such as ‘every two weeks’ could be used.
- Completeness: Describes the scope of coverage of the EA artefact. Some EAs in practice are intentionally limited by certain parameters, such as location or organizational departments. For this attribute, individual values can be used.
- Importance: Some EA artefacts are detrimental for certain EA products. Others can be just nice to have. With this attribute the user of the catalogue gets the possibility to include other not-listed attributes such as correctness or usefulness of EA artefacts. Proposed values for importance are low, medium or high.

Section B should be assessed for all EA artefacts and IS that are part of the evaluation before progressing to *Section C*. This makes it clear for the user, what exactly he is looking for when evaluating the potential sources in the next steps.

To continue the example of the PPMDB, *Figure 5-11* illustrates that provided EA artefact is ‘Projects’ and that this artefact should be updated daily, is of medium importance and that the EA only covers IT-Projects.

5.2.2.3 Section C: Quality attributes of the source IS

C	Quality attributes of the source IS	Level of Granularity	[Coarse grained; Medium Grained; Fine Grained]	Coarse grained
		Consistency	[Low; Medium; High]	High
		Actuality	[Hourly; Daily; Weekly; Monthly; Yearly]	Daily
		Completness	[Whole Organization; Restrictions to Org Units, Locations; Defined Sub-Set; ...]	All IT-Projects
		Constraints	[Security; Performance; Availability; Technology]	- Tool only supports Spreadsheet based Export

Figure 5-12: Section C of the evaluation catalogue with example

In *section C*, the IS has to be further analyzed. As to main challenges of automated EA data collection are the level of granularity and consistency of data in the source systems (see *chapter 4.2.4*), they have to be taken into account in the assessment of IS. *Section C* further takes a look at the attributes actuality and completeness, for which requirements were defined in *section B*. The last step is to analyze possible constraints for data collection from the corresponding IS.

- Level of Granularity: The level of granularity seems to be one of the most deciding factors when it comes to automating EA data collection (Farwick et al. 2013; Hauder et al. 2012). The more fine grained the available data is structured in the source IS, the more effort is required to automate the EA data collection because the data has to be transformed. Suggested values for the level of granularity are coarse grained, medium grained and fine grained.
- Consistency: It is possible that even data in a productive IS can contain errors or be inconsistent (Farwick et al. 2013; Hauder et al. 2012). It is therefore important to asses this attribute before automating the EA data collection. Proposed values are low, medium and high.
- Actuality: Depending on the actuality requirement of the EA artefact, the data source needs to contain similar or more up-to-date data. It is possible that data in the source system is updated infrequently or that it changes in extremely fast cycles. Since this has an impact on the design of automated data collection, the actuality attributes needs to be assessed. Possible values are hourly, daily, weekly, monthly or yearly or individual values such as ‘two times a day’.
- Completeness: Data in the source system can be limited in some dimensions similar to the ones mentioned in *section D* of the catalogue. It needs to be analyzed if the source covers the required range of the concerning EA artefact.
- Constraints: Depending on the organization, the IS or the data, there can be several constraints for automated data collection. Examples are security concerns, performance issues, restricted availability and technology limitations.

Figure 5-12 shows the assessment of the example PPMDB. The data is available on a coarse grained level, is very consistent, can change daily, covers only IT-Projects and can only be exported in a spreadsheet format.

5.2.2.4 Section D: Economic factors

D	Economic factors	Cost of automated collection	[Low; Medium; High]	Low
		Cost of manual collection	[Low; Medium; High]	Medium
		Is it expected to have better data quality with automated collection	[x; " "]	x

Figure 5-13: Section D of the evaluation catalogue with example

Section D contains the assessment of economic factors. The potential cost of implementing an automated EA data collection with the specific IS is estimated. It is important to estimate the cost for the implementation of an interface, but also to consider the additional cost that is generated when the automated data collection is in use. As pointed out by research and practice, even with automated data collection implemented, there are still recurring manual efforts required to resolve conflicts or commit changes to the EA (Farwick et al. 2011a; Farwick et al. 2014). This cost is then compared to one of the following:

- If at the moment the data from the source is not collected at all, it is estimated how much effort a manual collection would require. Both the initial build-up and the continuous manual maintenance of the data are estimated.
- If the data from the source is already manually collected, it should be measured how much recurring effort is required.

The costs and efforts can have exact values if analyzed in detail. Approximation values such as low, medium and high can be used if only a rough analysis is made. A detailed analysis has the advantage to show in what timeframe an automated data collection technique would reduce or increase the total effort required.
Based on the previous assessments in *sections B* and *C* it should further be evaluated, if an increase in quality of EA artefacts can be expected if automated data collection is used.

Figure 5-13 the assessment of the PPMDB concerning economic factors. A rough analysis has shown that the current manual collection of data requires medium effort and both the cost and effort of automated data collection would be low. Since the EA stakeholders require daily reports where the EA artefact ‘projects’ is needed, an automated data collection for this EA artefact could benefit the quality of the EA.

5.2.2.5 Section E: Documentation technique

E	Documentation technique	Recomended method	[automated data collection; manual data collection; use of external events; use of internal events]	automated data colleciton use of internal events
		Priority	[Low; Medium; High]	Medium

Figure 5-14: Section E of the evaluation catalogue with example

In the last section of the evaluation catalogue, a documentation technique is chosen the EA data collection from the specific IS and the implementation this technique is given a priority. In *chapter 5.1.3* four different documentation techniques are described that can be used in parallel for different EA artefacts. The assessments in the previous sections of the catalogue support the selection of a suitable documentation technique for the evaluated IS.

As each organization possesses individual EA and IS landscapes, it is difficult to provide an exact formula for the selection of the documentation techniques. To support a decision, *Table 5-5* compiles a list of beneficial assessments for each documentation technique.

Documentation Techniques	Evaluation Catalogue Section	Beneficial Factors
automated data collection	*Section B*	- required actuality is rated hourly, daily or weekly - importance of artefact is rated medium or high
	Section C	- level of granularity is coarse grained or medium grained - consistency of data is rated high - actuality of data is rated hourly, daily or weekly - completeness in data source fulfills required completeness of artefact - as few constraints as possible
	Section D	- estimated cost of automated collection is lower than cost of manual collection - it is expected that automated data collection would increase the data quality
manual data collection	*Section B*	- required actuality is rated weekly, monthly or yearly
	Section C	- level of granularity is fine grained - consistency is of data rated medium or low - actuality of data is rated weekly, monthly or yearly - completeness in data source does not fulfill required completeness of artefact - there have several constraints for automated collection been identified
	Section D	- estimated cost of automated collection is higher than cost of manual collection - it is not expected that automated data collection would increase the data quality
use of external events	*Section B*	- required actuality is rated hourly, daily or weekly - importance of artefact is rated medium or high
	Section C	- actuality of data is rated hourly, daily or weekly
	general	- the use of external events should be considered when the source IS cannot provide structured data but still are relevant sources for EA change events
use of internal events	*Section B*	- importance of artefact is rated medium or high
	general	- internal events should be considered when automated collection is not possible and there are no external events available

Table 5-5: Beneficial factors for each documentation technique

Figure 5-14 illustrates the selection of automated data collection as documentation technique for the example PPMDB.

Chapter 6 – Case-Study Evaluation of the Catalogue

This chapter is concerned about the evaluation of the developed product. The first *chapter 6.1* explains why an evaluation is needed and how the evaluation in this thesis is implemented with a case-study. *Chapter 6.2* then presents the case-study and the application of the product in the presented case including feedback from practice. *Chapter 6.3* discusses the results of the case-study and inspects if the product fulfils the previously defined requirements for a solution.

6.1 EVALUATION TECHNIQUE

In design science in information systems research it is expected, that the created products and artefacts of the research process are evaluated with suitable methods and criteria (Hevner et al. 2004). According to Hevner et al. (2004) there are several methods available such as case studies, field studies, different types of analysis, experiments, simulations, functional and structural testing or descriptive evaluation. For the evaluation of the in *chapter 5.2* developed data source selection catalogue for EA documentation a case-study has been chosen because the case-study is suitable method to assess the practical value and feasibility of a developed artefact in the environment (Hevner et al. 2004).

In general, case studies are performed when the focus is on a contemporary phenomenon within a real-life context and is most likely to be appropriate for ‘how’ and ‘why’ questions (Yin 2009). Yin (2009) also agrees with Hevner et al. (Hevner et al. 2004) that case studies have a distinctive place in evaluation research. For this thesis, a holistic single case-design has been chosen (Yin 2009). The chosen case of ‘EA documentation in PostFinance’ should be a typical example for how the developed catalogue can be applied to the situation and structures of an existing enterprise.

The case-study at PostFinance was conducted according to a predefined structure, in order to increase its representativeness:

1. Definition of case-study questions
2. Data Collection Procedures
3. Application of the product to the case
4. Descriptive Evaluation

The concrete elements of the case-study structure are presented in *Table 6-1*.

Case-study structure	Concrete case-study elements
1. Definition of case-study questions	- How is EA documentation organized in the case? - How can the catalogue be applied to the case? - How can the case profit from the catalogue?
2. Data Collection Procedures	- Document study - Focus Group Workshops
3. Application of the product to the case	- 'Coverage of essential EA artefacts within common information systems'-matrix is applied to the EA artefacts and IS landscape of the case - 'Evaluation Catalogue for potential EA Documentation sources' is applied to potential EA Documentation sources of the case
4. Descriptive Evaluation	- Fulfilment of the requirements is examined in the case-study's environment

Table 6-1: Case-study structure and its concrete elements

6.2 CASE-STUDY

PostFinance has been chosen as the environment for the case-study. Since several years EAM has been applied in the organization, especially so in the IT department. There already have been multiple EA efforts with more or less success. In 2010 an EA repository was implemented and holistic EA meta-model was defined. Since then, the organization has faced several problems with the maintenance of the EA documentation. Even though some forms of automated data collection have been implemented, the quality of EA documentation does not fulfil the expectations of management. For these reasons the enterprise has been chosen as case-study environment for the evaluation of the data source selection catalogue for EA documentation developed in this thesis.

6.2.1 Introduction to PostFinance[1]

PostFinance AG is a Swiss financial service provider with headquarters in Bern and is an affiliated company of the Swiss Post AG. PostFinance belongs to the leading financial institutes in Switzerland. Since 1906 the company provides a nationwide payment service. In 1996 the company evolved from offering a post and girocheque service to a fully-fledged retail financial institution. Since then offered products and services have grown reasonably and include services in all financial categories: paying, saving, financing, investing and retirement planning. With a market share of around 60 percent, PostFinance is Swiss market leader concerning payment transactions and online banking users. At the end of 2013 PostFinance administers around 3 million customers and the customer assets reached a new all-time high of 112.03 billion CHF. The company counts around 3'400 employees, from which 800 work in the IT-department. The annual earnings before taxes accounted for 856 million CHF in 2013.

[1] Information has been taken from the company's webpage (https://www.postfinance.ch/en/about/company.html). Last accessed on 23. January 2015.

6.2.2 History and current situation of EAM and EA documentation in the organization

Architecture topics have a long history at PostFinance. In the early years architecture was purely done in the IT-department and from an IT-perspective. In 2005 an initiative for a holistic EA was launched in a centralized management department. The focus was to build a supportive EA function for management, which includes both functional and technical structures. The EA initiative built an as-is model of the EA and had some success and management acceptance in its first years. Due to difficulties with maintaining the quality of the EA model, the EA initiative lost more and more management support and the organizational EAM function got reduced to only basic ad-hoc analysis in 2008. The centralized as-is EA model got scraped.

In the absence of an EA tool and with a more and more growing IS landscape, the IT-department felt the need to strengthen their architectural function. In 2009 a new architecture initiative was born in the IT-Strategy & Governance department that, at first, focused heavily on the IT-architecture but gradually included more and more artefacts of the business architecture in the meta-model as well. In 2010 a new EA tool was implemented that represented a repository for the as-is model and for multiple states of the to-be model.

The initial build of the EA model was accomplished with a centralized effort. For the maintenance of the architectural model it was decided to establish a federated concept, which put the responsibility of documenting the technical and IT-system related artefacts almost exclusively into the hands of over one hundred application owners scattered in the IT-department. For artefacts in the business architecture the responsibility was given to the financial controlling team of the IT-department. Other artefacts were covered with ‘solution architects’, who supported IT-projects in the development and documentation of suitable project architectures. As a consequence of this federated approach, several dependencies started to grow. The financial controlling team started to use the model for service level agreement calculation and cost distribution processes. As such an automated export from the EA tool to the enterprise resource planning tool (ERP) was built. The IT-operation team recognized the value of the documented relationships between all the technical and IT-system related artefacts and incorporated the model into their IT service management suite (ITSMS) and into their configuration management database (CMDB). Again an automated interface was built that exported the model out of the EA-tool.

The created dependencies were seen as beneficial. It had the advantage that the maintenance of most EA artefacts was delegated to other teams and the IT-Strategy & Governance could focus on other EA tasks. However, in recent years it was discovered that the EA documentation diverged more and more

from the real EA. In 2013 when a major core banking transformation project was initiated and the EA documentation was analyzed, it was found that the EA meta-model became very detailed and specific over the last four years, containing many different artefacts with a huge number of attributes. It was also found the quality of EA documentation was low for several important artefacts. Therefore the EA documentation was deemed as not usable and the project had to initiate a detailed investigation of the current architecture.

In the wake of the events, the IT-Strategy & Governance team just recently (end of 2014) decided to initiate a new company wide EA effort and is currently in the process of gathering a centralized team of EA architects. The future EA documentation should build upon what exists, which is the current EA repository and the information that is being created in the core banking transformation project. IT is planned to apply a mix between a federated and centralized EAM approach, where the federated part lies in the data collection from current systems and a centralized team is simultaneously responsible for maintenance of the EA documentation.

The case-study takes place in an organization that has a long history and many experiences with EAM. *Table 6-2* answers the case-study question of *"how is EA documentation organized in the case?"* and summarizes the concrete setting of the case.

How is EA documentation organized at PostFinance?
Most of the EA artefacts are maintained with a federated approach people scattered in the IT-department.
There is no clearly described maintenance process.
Automated data collection is only used for very few EA artefacts like 'projects' or 'persons'.
Several automated exports to other IS like CMDB and ERP are in place, which result in dependencies.
Data collection for the exported EA artefacts is done manually in EA tool by a department-wide user-base.
Data quality is lacking; EA documentation is not up-to-date; for big projects data has to be gathered separately.
The case shows similarities to the identified problems in practice. The main difference is that the EA tool acts as master repository for a lot of EA artefacts.

Table 6-2: Summarized EA documentation environnement at PostFinance

6.2.3 Application of the Catalogue

This chapter describes the application of the data source selection catalogue for EA documentation in the described environment of the case-study and is divided into two sub sections: Application of the coverage matrix in *chapter 6.2.3.1* and application of the evaluation catalogue in *chapter 6.2.3.2*.

6.2.3.1 Coverage of essential EA artefacts within common information systems

As a first step, the application of the coverage matrix developed in this thesis required a mapping of the EA artefacts and IS used in the matrix to the ones used in the case. Therefore the EA-meta-model and the IS landscape of PostFinance were analyzed. *Figure 6-1* shows the core EA artefacts and the EA Layers of PostFinance.

EA artefacts of PostFinance	Layers of PostFinance			
End-Product	Financial and Service Management	Business side		Transformation Architecture
Services SLA	Financial and Service Management			
Actor	Process Architecture			
E2E Processes Subprocesses	Process Architecture			
Business Areas Business Domains	Business Domain Architecture			
Service Domains	Business Domain Architecture			
Business information objects	Business Domain Architecture			
IT-Services	Service Architecture			
IT-Service Consumption	Service Architecture			
Applications External Partner Systems	Application Architecture	Information Technology	Projects	
Application Components	Application Architecture			
Core Data Type	Application Architecture			
Technology Technology Component Technology Stack	Technology Architecture			
Infrastructure Component	Technology Architecture			

Figure 6-1: EA artefacts and EA layers of PostFinance

It can be seen that PostFinance uses similar EA artefacts to the ones identified as essential in this thesis (see *chapter 5.2.1.1*). There are some stronger differences in the structure of the EA layers, which proved not to be an obstacle in further steps of the application. After the EA artefacts of PostFinance were examined in a bit more details, it was possible to map most of them to the EA artefacts of the coverage matrix, as seen in *Figure 6-2*.

In a next step it IS landscape of PostFinance was investigated in an effort to map IS of PostFinance with the IS listed in the coverage matrix (see *chapter 5.2.1.2*). In order to protect the privacy of PostFinance, no software producers or brands are named. Instead it is indicated with a tickmark and blue coloring if an appropriate IS was found. *Figure 6-3* presents the result of the IS analysis.

EA Layers of coverage matrix	EA artefacts of coverage matrix	EA artefacts of PostFinance	EA Layers of PostFinance	
Business Architecture	Goals	-		Business side
	Product model	End-Product	Financial and Service Management	
	Projects	Projects	Transformation Architecture	
	Core Capabilities	(Service Domains)	Business Domain Architecture	
	Metrics	-		
Process Architecture	Organisational Units	Business Areas Business Domains	Business Domain Architecture	
	Organisational Roles	(Actor)	Process Architecture	
	Business Processes	E2E Processes Subprocesses	Process Architecture	
	Business Services	Services SLA	Financial and Service Management	
	Business information objects	Business information objects	Business Domain Architecture	
	Information Flows	(IT-Service Consumption)	Service Architecture	Information Technology
Integration Architecture	Applications	Applications External Partner Systems	Application Architecture	
	Application Components	Application Components	Application Architecture	
	IT-Services	IT-Services	Service Architecture	
Software Architecture	Software Components	-		
	Data models	Core Data Type	Application Architecture	
Infrastructure Architecture	Technology Components	Technology Technology Component Technology Stack	Technology Architecture	
	Hardware Units	Infrastructure Component	Technology Architecture	
	Network Nodes	-		

Figure 6-2: Mapping results of EA artefacts and layers

✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×	✓	✓	×
ERP	HRM Tool	BI Tool	PPM Tool	BPM Tool	CMDB	Change Mgmt DB	ITIL-Service Mgmt Tool	Release Mgmt Tool	Development Repository	SOA Serice Repositories	Enterprise Service Bus	Network Scanners	License Management Tool

Figure 6-3: Results of IS landscape analysis

The third step the IS were examined in a little bit more detail in order to identify some IS that could potentially serve as data or event sources. As predicted in *chapter 5.2.1.3*, the predefined mapping of EA artefacts to IS had to be adapted quite heavily. However, the predefined mapping was still useful as it initiated the analysis and gave some ideas of what to look for. *Figure 6-4* shows the potential EA data sources that have been identified, while *Figure 6-5* shows the potential EA event sources. IS that contained no EA data (Development Repository, BI Tool) or no EA relevant events (ERP, HRM Tool, BI Tool, ITIL-Service Mgmt Tool, Development Repository, Network Scanners) are not displayed in the corresponding figure.

As already pointed out in the description of the case (see *chapter 6.2.2*), some of the potential EA data sources (ERP, CMDB and ITIL Service Management) are importing the EA data from the EA repository. As such, they cannot be considered as potential EA data sources for the next steps. However, in the future, the IT-Strategy & Governance department may consider the option of shifting the responsibility and maintenance of the correlating EA artefacts into these IS based on the observations of this case-study.

IS in PostFinance common IS EA artefacts PostFinance	✓ ERP	✓ HRM Tool	✓ PPM Tool	✓ BPM Tool	✓ CMDB	✓ ITIL-Service Mgmt Tool	✓ Release Mgmt Tool	✓ Enterprise Service Bus	✓ Network Scanners
-									
End-Product	x								
Projects			x						
(Service Domains)									
-									
Business Areas Business Domains									
(Actor)		.		.					
E2E Processes Subprocesses				x					
Services	x					.			
Business information objects									
(IT-Service Consumption)	.				.			x	
Applications External Partner Systems					x	.	.		
Application Components					x	.		x	
IT-Services	.				x	.		x	
-									
Core Data Type									
Technology Technology Component Technology Stack					x				x
Infrastructure Component					x				x
-									

Figure 6-4: Coverage of EA artefacts in potential EA data Sources

IS in PostFinance common IS EA artefacts PostFinance	✓ PPM Tool	✓ BPM Tool	✓ CMDB	✓ Release Mgmt Tool	✓ Enterprise Service Bus
-					
End-Product	Project start, Gate, End			A Change gets mapped to a Release	
Projects					
(Service Domains)					
-					
Business Areas Business Domains	Project start, Gate, End			A Change gets mapped to a Release	
(Actor)					
E2E Processes Subprocesses		Changes to E2E Process			
Services SLA					
Business information objects					
(IT-Service Consumption)					New user of service Service lost a user
Applications External Partner Systems			New CI, Change in a CI		
Application Components					
IT-Services					
-					
Core Data Type	Project start, Gate, End			A Change gets mapped to a Release	
Technology Technology Component Technology Stack			New CI, Change in a CI		
Infrastructure Component					
-					

Figure 6-5: Coverage of EA artefacts in potential EA event sources

Also excluded for the next steps containing the evaluation of potential EA data sources are those IS, where an automated data collection is already in place (HRM Tool, PPM Tool) and also the ones, where only a partial coverage of EA artefacts was identified (Release Mgmt Tool).

This leaves the IS listed in *Table 6-3*, that is evaluated as potential EA documentation sources. The complete coverage matrix of the case-study is provided in *Appendix C*.

Evaluated IS from PostFinance	Potential data source	Potential event source	Impacted EA artefacts by data or events
PPM Tool		✓	All artefacts
BPM Tool	✓	✓	E2E processes, Sub processes and relations to these artefacts
CMDB	□	✓	Configuration Items: Application Components, Technology Components, Infrastructure Components
Release Mgmt Tool		✓	All artefacts
Enterprise Service Bus	✓	✓	Applications, Application components, IT-Service, IT-Service Consumption
Network Scanners	✓		Technology Components, Infrastructure Components

Table 6-3: List of PostFinance IS identified as potential EA documentation sources

6.2.3.2 Evaluation Catalogue for potential EA Documentation sources

Together with a focus group inside the IT-Strategy & Governance team, the candidates for automated EA documentation have been analyzed. Considering the time limitation of the thesis, the analysis has been kept on a conceptual level, which means no detailed analysis of data models or elaborate cost calculations were created. For each potential EA documentation source, the focus group followed the procedure of the evaluation catalogue. In the end, a recommendation for a documentation technique was produced for every source except for one, where the group concluded a more detailed analysis is needed. The completed evaluation catalogue is presented in *Figure 6-6*.

ID		1	2	3	4	5	6
Source IS		PPM Tool	BPM Tool	CMDB	Release Mgmt Tool	ESB	Network Scanners
Type of source	Data source		x			x	x
	Event source	x	x	x	x	x	
Provides information about EA artefact		Projects (could have impact on all artefacts)	E2E processes, Subprocesses and relations to these artefacts	Configuration Items: Application Components, Technology Components, Infrastructure Components	(could have impact on all artefacts)	Applications, Application components, IT-Service, IT-Service Consumption	Technology Components, Infrastructure Components
Quality requirements of the EA artefacts	Actuality	-	Monthly	Weekly	-	Weekly	Weekly
	Completness	-	All Processes on Level 0 (E2E) and Level 1	Complete (Whole company, both datacenters included)	-	Not every individual service call, but general information flow and service consumption structure	Complete (Whole company, both datacenters included)
	Importance	Normal	High	High	Normal	High	High
Quality attributes of the source IS	Level of Granularity	Coarse grained	Medium grained	Medium grained	Coarse grained	Fine grained	Very Fine grained
	Consistency	High	Medium	Medium	-	High	Medium
	Actuality	Daily	Weekly	Daily	Weekly	Daily	Daily
	Completness	High	High	High	Medium	Low	High
	Constraints of the source IS (Security, Performance, Technology)	None	- System is under heavy load on weekends (publication run) - Tool supports only Excel Exports	- Tool is still in a multi-year implementation process (internal processes are not final)	None	None	- Tool will be replaced in one year
Economical factors	Cost of automation collection	Low	Medium	High	Medium	High	High
	Cost of manual collection	Medium	Medium	High	Low	High	High
	Is it expected to have better data quality with automated collection	x	x	x		x	
Score	Recomended method	use of external events	automated data collection use of external events	use of internal events	use of internal events	More detailed analysis needed	Manual data collection
	Priority	3	1	2	-	2	-

Figure 6-6: Completed evaluation catalogue for potential EA documentation sources in PostFinance

Following is the reasoning for the recommendation of documentation techniques for each potential EA documentation source.

1. **PPM Tool:** Today, the PPM Tool is already an EA data source and projects are automatically imported into the EA repository. However, the projects still have to be manually connected to other EA artefacts and project state changes are not included in the import. Since the data model at the source system is very coarse grained and data quality seems generally very high, it would also be interesting to detect project state changes in the PPM Tool itself and implement some kind of trigger. It could prove as really helpful if the event source automatically sends a notification to the EA tool when projects change states (e.g. from design phase to implementation phase), in order to indicate that other artefacts in the EA model that are connected to the project need examination. Since the current manual observation of project state changes requires a lot of effort and some projects state changes are sometimes forgotten, the focus group strongly considers to use the documentation technique ‘use of external events’ for this source.
2. **BPM Tool:** The BPM Tool was implemented two years ago and the enterprise has just finished a big process documentation initiative. The process artefacts in the EA repository are only rarely maintained and as a consequence are very far from reality. Since the EA artefact E2E processes and their sub-processes have recently gained more management attention, the automated collection of these artefacts would be extremely beneficial. The data in the BPM Tool is medium grained, which means some data transformation efforts for implementing the

interface has to be expected. Additionally, the BPM Tool should trigger a notification if a process is being updated, which doesn't happen too often. With this, an architect could examine the impact on the relations to other EA artefacts. The focus group strongly considers using the documentation techniques 'automated data collection' and 'use of external events' for this source.

3. **CMDB:** At the moment the CMDB cannot be considered as EA data source, because the data is originating from the EA tool anyway. The CMDB further enriches this data with specific information and this sometimes has the consequence that the originating artefact needs to be updated in the EA repository. However, the focus group identified a high effort for implementing an interface. Additionally, the IS is still in a multi-year implementation phase and internal processes are not finalized yet. The focus group decided to keep the current method of maintaining those artefacts and considers the 'use of internal events', such as expiry dates or periodical assessments.
4. **Release Mgmt Tool:** It was quickly recognized that the Release Mgmt Tool could only provide events about planned IT changes, which get mapped to a release date. At the moment PostFinance only uses two release cycles during a year. The manual effort to periodically check these releases periodically is very low. An automated interface to collect events from the Release Mgmt Tool would not be feasible for economic reasons. The focus group decided to keep the current method of maintaining those artefacts and considers the 'use of internal events', such as expiry dates or periodical assessments.
5. **ESB:** It was identified that the enterprise service bus of PostFinance contains highly useful information about the EA artefacts. The ESB knows about application dependencies, information flows between application and can list consumers of IT-services. This data would definitely help to improve the quality of the EA documentation. However, there are two main problems. The data is only available in a very fine grained granularity, which implies a high transformation effort when considering automation. The other problem is that not all applications are communicating over the ESB and the data would only represent a fraction of the actual architecture. Because the benefits could outvalue these problems, the focus group decided that a more detailed analysis is needed in order to decide on a documentation technique.
6. **Network Scanners:** The data structure in the network scanners is very fine grained and it was difficult to relate the data to EA artefacts. This in combination with the constraint, that the tool will soon be replaced made the focus group decide on keeping the current manual documentation technique.

6.3 EVALUATION

The case-study and application of the product at PostFinance followed a structured approach, which was defined independently of the actual case. Therefore, the results of the case-study can be generalized to some degree and used to evaluate the usefulness, effectiveness and relevance of the developed product. To achieve this, the results are described and discussed in *chapter 6.3.1*. Afterward the defined requirements are evaluated with the outcome of the case-study in *chapter 6.3.2*.

6.3.1 Discussion of Case-Study Results

The case-study identified similar problems and challenges of EA documentation as were formulated in the research results of this thesis (see *chapter 4.3.1*). The examined organization has not defined or described a specific maintenance processes for keeping the EA documentation up-to-date and consistent are defined. As a probable consequence, the quality of the EA documentation is not holding up to expectations of management and to the needs of company-wide projects.

The application of the data source selection catalogue for EA documentation was able to identify potential EA data and EA event sources and recommend suitable documentation techniques for them. According to the results, some of the sources even qualify for automated EA data collection and when implemented, are expected to have a positive impact on the level of data quality in the EA repository. Other sources can provide notifications about EA change events, which would also help to maintain the EA documentation in an easier fashion. Other IS were initially included in the analysis and it was possible to exclude them as potential EA documentation candidates with proper argumentation. Generally the catalogue provided a step-by-step approach to reach a concrete decision about which IS should be integrated and which documentation techniques would be suitable.

The case-study also showed that some enterprises can have very intricate situations regarding their organization of EA documentation. In this case, the dependencies of the EA tool to other IS in the landscape made the set of possible EA data sources to choose from automatically smaller. This leaves us with the possibility, that in another case no potential EA sources could be identified. In such a case, an application of the selection catalogue would still force EA teams to think about their maintenance concept and identify weakness in their current setup.

6.3.2 Fulfilment of Requirements

In *Table 6-4*, the fulfilment of the defined requirements of chapter is descriptively evaluated with the results of the case-study. The case-study showed that most of the requirements are completely satisfied. Some shortcomings of the solution have to be attributed to the absence of a clearly defined rating system for the assessment of the quality criteria and the evaluation of the economic factor. The

author believes that due to the all the differences of IS landscapes and EA priorities of different organizations, it would be nearly impossible to define a universally applicable rating system. Therefore including detailed rating systems with different weighting of the criteria was dismissed.

Requirements for a solution	Result of solution application in the case-study
The solution should include the essential EA artefacts mentioned in *chapter 4.2.1*.	The solution includes the essential EA artefacts. In the application these artefacts can be compared and mapped to organization-specific artefacts. In the case-study, the essential artefacts covered the organization specific artefacts well.
The solution should contribute to a defined EA documentation maintenance concept. (see *chapter 4.2.2*)	The case-study indicated that a well-defined maintenance concept is missing. The application of the solution provided an overview over potential EA documentation sources and recommended suitable documentation techniques for them. These results definitely helped structuring the EA data collection and contributed parts of a maintenance concept.
The solution should be applicable in a centralized, federated or mixed EAM approach (see *chapter 4.2.3*)	The case-study showed that even in an almost completely federated approach, the catalogue was applicable and produced additional source candidates. It remains unproven, if the catalogue can be applied in a completely centralized approach, even though there was no indication found that it could not.
The solution should address the challenges of automated EA data collection, namely level of granularity, cost of implementation, low data quality at EA sources and data responsibility (see *chapter 4.2.4*).	Even though the solution addresses the challenges, it gives no detailed guide how to assess these criteria, but only that they have to be assessed in some form. The application in the case-study showed that in some cases a detailed analysis of those criteria is needed.
The solution should provide a set of potential EA data and event source candidates (see *chapter 4.2.5* and *chapter 4.2.6*)	The application of the solution in the case-study clearly showed, that even though some candidates had to be excluded, a healthy set of source candidates were identified. Some of them were never before considered as potential EA sources.
The solution should describe a method to assess potential EA data and event sources and recommend suitable EA documentation techniques (see *chapter 4.2.5* and *chapter 4.2.6*)	The general overview and structured step-by-step approach of the solution helped the application in the case-study. It was beneficial to have a guideline and to know what needs to be looked at. The recommended documentation techniques were clearly distinguishable and it was possible to assign a suitable technique to each source. The variety of documentation techniques provided additional incentive to improve EA documentation maintenance, because not only data, but also events are considered.
The solution should consider the success factors of EA documentation (see *chapter 4.2.7*) in its recommendation of EA documentation techniques.	The solution makes it clear that cost and time effort need to be evaluated and that the implementation must have a positive impact on the quality. Even though no detailed rating system is provided, it became clear which documentation technique is recommended most cases. However, sometimes only detailed calculations can really provide support for a decision.

Table 6-4: Fulfilment of the requirements for a solution

Chapter 7 – Conclusion

In this chapter, the essential results of the thesis are summarized and (*chapter 7.1*) and the research questions are answered (*chapter 7.2*). Following a reflection on the chosen research approach (*chapter 7.3*) the contribution and limitations of the thesis are examined (*chapter 7.4*). The end of the thesis constitutes of a recommendation and an outlook for future research directions (*chapter 7.5*).

7.1 SUMMARY OF RESULTS

The introduction (*Chapter 1*) illustrated that today's organizations have to cope with a continuously growing complexity of their business execution and IT-infrastructure, and are exposed to increasingly frequent change of its environment. The purpose of EAM is to master the complexity and make an enterprise more agile by providing transparency of its architectural structures. In order to facilitate such transparency, the documentation of the EA has to be manifested in proper quality and according to defined processes.

In the literature review (*Chapter 2*) EAM, as a management discipline, was described in details. The three main functions of EAM were presented as the documentation and analysis of the current architecture, the development of target architectures and the accomplishment of architectural transformation. The first function of establishing a holistic view of the current EA was identified as a prerequisite for the accomplishment of the other two functions. It was found that a holistic view is created by describing and documenting the architecture over several layers. Such documentation often takes the form of an EA model that contains multiple highly aggregated artefacts. The examination of several EA frameworks was summarized. The contents of EA frameworks encompass the structure of EA models and definition of methodologies, of how such models have to be created. However, the analyzed EA frameworks showed significant gaps concerning the organization of the maintenance of EA documentation. Concrete examples or methods for maintaining a high quality documentation of the EA were not found.

Chapter 3 provided an overview of the research approach. The choice of research philosophy and research design was discussed and the research design and data collection process was explained. It was presented how the design science research paradigm can be applied to this specific research. The chapter provided reasoning for the selection of data collection methods for the individual research phases.

Chapter 4 contained a detailed review of literature specifically about EA documentation and assessed the relevance of the findings with EA practitioner interviews. Insights from the literature were compared with experiences from practice in order to formulate a concrete problem statement. The chapter contained the analysis of seven different aspects of EA documentation and concluded with the formulation of specific requirements for a possible solution. It was found that:

- An EA consists of highly aggregated artefacts that can origin from specialized architectures of the enterprise.
- While the initial creation of the initial EA documentation can be time consuming, having a defined maintenance concept or a described maintenance process is essential and is often missing in practice.
- Maintenance of EA documentation is neglected in most EAM approaches. A mix of the centralized and the federated EAM approach is found in practice.
- Information about EA artefacts has to be collected from different sources and EA documentation could highly benefit from automated EA data collection
- In practice EA data is mostly collected manually because there are several key challenges of automated EA data collection.
- Sources of EA artefacts can be productive IS and several potential candidates were identified in research and practice. Key challenges exist for selecting suitable IS as sources
- Productive IS also contain information about changes to the EA which can support automated EA documentation. Since the selection, detection and automated incorporation of external events is challenging, events are mostly incorporated manually in practice.
- Even though success of EAM is generally difficult to measure quantitatively, it is clearly influenced by the quality of the EA documentation.

In *Chapter 5* several existing artefacts from literature that address the stated problem were analyzed in order to formulate a suggestion. After an iterative development of the suggested product, the final solution was described. The final product was the data source selection catalogue for EA documentation that consisted of two parts:

1. A coverage matrix of essential EA artefacts within common IS, which provides researchers and EA practitioners with a compendium of potential EA data and event source candidates.
2. An evaluation catalogue for potential EA Documentation sources, which gives EA practitioners a way to select a suitable documentation technique for each potential source and to improve their quality and maintenance of EA documentation.

Chapter 6 discussed the choice of the case-study as an appropriate evaluation method and described a structured approach for the case-study execution. The environment of the case was analyzed in details

and the solution was applied and tested. The results indicated a fulfilment of the previously defined requirements. The resulting contribution and limitations of the thesis are addressed in *chapter 7.4*.

7.2 THESIS STATEMENT AND RESEARCH QUESTIONS

The goal of this thesis was to validate the following thesis statement.

> The required information to create, maintain and improve the documentation of the EA can be found in common information systems of an enterprise.

In order to validate this statement, it was split up into the following research questions.

RQ1: What is EA relevant information?

The detailed literature review about EA documentation and the EA practitioner interviews identified that EA relevant information is either detailed data about concrete EA artefacts or EA change events that have an impact on the EA artefacts. A concrete list of essential EA artefacts was provided in *chapter 4.2.1* and a possible set of relevant EA change events was presented in *chapter 0*.

RQ2: Which common IS contain EA relevant information?

This question has been thoroughly addressed in *chapters 4.2.5*, *4.2.6*, and *5.2.1.2*. In the latter mentioned chapter, *Table 5-4* summarizes all IS that could contain EA relevant information and provides references of literature and interview participants that mentioned them.

RQ3: Can EA documentation profit from EA relevant information in common IS?

In *chapter 4.2.4* it was argued by researches and EA practitioners that information about the EA artefacts has to be collected from different sources and one of the most popular sources are the contents of IS. Additionally several researchers agreed that EA documentation can highly benefit from automated EA data collection from other IS. During the case-study evaluation several IS were identified as potential sources that would have a positive impact on the quality of EA documentation.

RQ4: What are key performance indicators for EAM?

This research question was not answered in its entirety as only the documentation aspect of EAM was investigated. *Chapter 4.2.7* concluded that the success of EAM is generally difficult to measure quantitatively. However, the quality of the EA documentation is main influencing factor for the success of EAM. It was summarized that the success of automated EA documentation can be measured with time savings compared to manual methods and with increased quality indicators of the EA documentation such as actuality, consistency and completeness.

RQ5: In which way can the EA relevant information in common IS be used to improve the EA maintenance?

During the suggestion of a solution similar artefacts of other researches were analyzed and useful elements were identified. These elements were brought together in the data source selection catalogue for EA documentation. An application of the catalogue on the one hand identifies IS that serve as potential source candidates and on the other hand provides a guided method for evaluating these IS in order to recommend a suitable documentation technique for each of them. As such the application of the catalogue presents ways, how EA relevant information is found in common IS and used appropriately to improve the documentation of the EA.

To conclude this chapter, the thesis statement can be proved on the basis of the answers to the research questions. Information to create, maintain and improve the EA documentation can be found in common information systems of an enterprise.

7.3 Reflexion of Research Approach

The design research paradigm proved as suitable approach to combine insights from literature and experiences from the practical environment in every step of the research. In order to understand and define a concrete problem statement, multiple iterations with literature reviews and practitioner interviews were necessary. This thesis tried to develop a solution that is both relevant in practice and adds a contribution to the research community. As the research questions could be answered and the developed solution proved to fulfil the requirements in a practical case, this thesis successfully faced this challenge.

7.4 Contribution and Limitations

First, this thesis summarized and visualized existing literature regarding the motivation, goals, and functions of EAM and commented on the state current EAM literature and frameworks. The problems and challenges of EA documentation were formulated in detail on the basis of interviews with EA practitioners. A set of requirements for a possible solution were formulated.

As the main contribution of this thesis, the data source selection catalogue for EA documentation was created. The first part of the contribution is a coverage matrix of essential EA artefacts within common IS. The coverage matrix on the one hand lists the identified essential EA artefacts and on the other hand shows IS that can contain information about those artefacts. It further includes a predefined mapping of these two elements that acts as a starting point for an analysis in a real world environment. The second part of the contribution is an evaluation catalogue that lists relevant data

quality criteria and provides a guided assessment of the identified IS. As an outcome the catalogue recommends an appropriate documentation technique for each assessed IS.

Both contribution parts have been evaluated in a practical case-study at PostFinance. It was shown that the data source selection catalogue for EA documentation successfully identifies IS that contain information about EA artefacts. It was further established that the catalogue provides appropriate recommendations for documentation techniques that would improve the quality of the EA documentation.

However, the evaluation has also identified certain limitations of the contribution. Firstly some of the mentioned IS candidates are not always implemented in an enterprise. Depending on the industry and size of the organization in question, the set of potential IS candidates can vary strongly. Additionally, depending on the IS landscape and dependencies between IS in the organization, some mentioned IS cannot be considered as potential source candidates. Secondly, the structure of EA artefacts vary between organizations and a complete mapping of the artefacts is not always possible. Thirdly the evaluation method in the catalogue is only conceptually described, and no detailed rating system is given. In complex and ambivalent cases, where multiple factors have to be analyzed in details, no immediate recommendation can be given. In such cases further effort is needed to reach a conclusion.

Since this thesis had a defined timeframe, only one case-study was executed. In order improve the assessment of the contribution and to investigate how the differences of organizations can be addressed, further case-studies could be the basis for additional development cycles of the data source selection catalogue for EA documentation.

7.5 Recommendations and Future Research Directions

Currently organizations are confronted with a multitude of EA frameworks and concepts that provide methods for integrating and utilizing EAM as a management discipline. Today, enterprises have to evolve faster and possess bigger IS landscapes than ever. This thesis presented that information about the EA architecture can be found in several commonly implemented IS and provided a method for selecting the appropriate IS and applying suitable techniques for collecting this information. It was presented that these results can have an impact on the success of an EAM initiative. As such todays popular frameworks should not only cover the creation of EA documentation, but should also include more details about the documentation techniques, data sources, event sources, and generally the maintenance of EA documentation as a critical aspect of EAM.

Additionally, future research can focus on the following aspects, which build upon the results and contribution of this thesis.

- **Cost-benefit analysis:** As the evaluation showed, the selection of appropriate documentation techniques can sometimes require a more thorough analysis of the source data models and more detailed cost calculations for the implementation of automated interfaces. Future research could focus on concrete implementation cases of automated EA data collection and develop a calculation method for how the model transformation necessities and the continuous usage of an automated interface can be assessed economically. The goal should be the development of a cost-benefit analysis model for automated EA data collection efforts.
- **Documentation techniques addressing the abstraction gap:** Understanding the abstraction gap between EA model and data models of IS better could also inspire the creation of new types of documentation techniques that address the different granularity levels more appropriately. In particular what needs to be looked at is how the deletion of an object in a data source can be detected and handled appropriately.
- **Automatic event handling methods:** The technique of using events from external systems to indicate EA changes is very promising. At the moment the events and their impact on EA artefacts still need to be manually analyzed and handled. Future research should identify methods for automatically relating such event notifications to certain EA artefacts. Even further, these methods should provide suggestions for model changes based on the events so that the required effort of the receiving architect is reduced as much as possible.
- **EA documentation quality measurement:** As a follow-up of automated data collection efforts in enterprises, there should be general usable approach to measure the data quality of the EA documentation. There is a multitude of ideas in literature and praxis for measurable data quality indicators but their usability and applicability remains uncertain. The focus should be on presenting concrete examples of implemented quality indicators and provide data to show how they can support the manageability of EA documentation.

From a broader perspective, further research should also support the evolution of interfaces between IS.

- **Interface standardization in EA-tools and other common IS:** Automated data collection requires a technical integration between two IS. Since a common obstacle of implementing automated collection methods are the cost considerations to build specific interfaces, research in the field of interface design and standardization should be continued with the goal that common implemented IS in an organizations already bring standard interfaces so that they can quickly be connected and exchange data with one another. This would reduce the required efforts and promote the implementation of automated EA data collection methods.

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Appendix A - Interview Notes

A.1 Participant 1

ID	Question German	Notes
1	Welche Informationen werden von EAM (UAM) benötigt? (Welche Funktionen werden in Ihrer Unternehmung durch EAM erfüllt?)	Schritte um EAM strukturierter einzuführen nach TOGAF (Business-, Daten-, Applikations-, Infrastrukturarchitektur) Projektscope: in erster linie geht es um die Produktionslandschaft (Applikation & Services, Schnittstellen) die gebraucht werden um meteorologische & klimatologiesche Produkte zu generieren --> es geht um die Fachapplikationen (nicht SAP, Office, usw.) Gebrauchte Informationen: Hauptsächlich Applikationen, Services, Applikationscluster, Applikationskomponenten, nebenbei ein wenig Business- und ein wenig Infrastrukturkomponenten, "Scripts"(Produkte / Technologien) Wenn der IST Zustand sauber zu erfassen gewesen wäre, hätte sich der Aufwand auf ca. 2 Mannjahre belaufen. Projekt BusinessContinuityManagement (wichtige Produkte / wichtige Prozesse) --> Scope auf BusinessContinuity relevante Applikationen eingeschränkt. Erfassung der IST/SOLL-Architektur wäre einfacher gewesen wenn Prozesse schon digital modeliert gewesen wären. Projekt war im Fach angesiedelt (Messungen und Daten) und nicht in der ICT. ICT war aber ein wichtiger Stakeholder, da sie speziell von der Aufnahme der Architektur (auch Infrastruktur) profitieren konnte. Datenarchitektur war schon weit fortgeschritten wegen 10 Jahre langes DWH Projekt. (Berechnungsvorschriften / Ablagevorschriften waren vorhanden) Nutzen der Architektur anderen aufzeigen indem man andere stakeholder und deren infos einbindet. Zuerst wurde nach Paretto-Prinzip (80/20) die IST-Architektur erfasst; dann verschiebt sich die Wichtigkeit in EAM auf die Pflegeprozesse der IST Architektur. Dazu wurden Architekturprinzipien bei der GL abgesegnet. Eines davon heisst "Jedes Architekturobjekt hat einen Verantwortlichen, der dieses Objekt pflegen muss aber auch Zeit davon bekommt". Spezialinformation: Verträge zu IT-Systeme (Beispiel für erweiterten Nutzen für einen Stakeholder (IT)). Diese werden aber auch durch den Stakeholder gepflegt. Datenflussdiagramme wurden früher mit VISIO gezeichnet und waren schnell veraltet. Im EAM Tool werden Änderungen nachgeführt uns die Diagramme sind zentral verfügbar. "Architektur entscheidet nichts sondern liefert nur Grundlagen für Entscheidungen"
2	Welche Artefakte bringt EAM hervor? Wie werden die gesammelten Informationen von EAM dokumentiert?	Safety Assessment (Pläne: welche Applikationen produzieren welche Produkte) Simple Listen Technologiemanagement (Versionen) Angebot flexible Sichten (keine Sichten auf Vorrat) - In einem ersten Schritt werden immer an einem konkreten Beispielen neue Artefakte generiert. Momentan keine Projektsicht (Ziel: Strategische Projektvorschläge) Projektführung (HERMES) in der Initialisierung wird Architekturrelevanz geprüft. Ende Konzeptphase gibt es Sollarchitektur welche im EAM Tool abgebildet wird. Am Ende Implementierungsphase wir IST-ARchitektur dokumentiert. Kein Übernahme Betrieb wenn Dokumentation nicht abgeschlossen. Deployment-Informationen.
3	Woher stammen EAM relevante Informationen?	Zu Beginn: Deployment- Betriebs Dokumentationen, Datenflussdiagramme, simplistisches Applikationsinventar in DWH, jede Menge Excel-Listen, wichtigste Quelle: SME / Knowhowträger "Dokumentenarcheologie" (RTFM) Prozess war Studie->Hypothese->Workshop mit SMEs->Dokumentation in EAM Tool->Review->Corrections EAM-Tool soll single point of truth sein (-->bedeutet nicht dass EAM-Tool der Master ist) Wenn etwas fehlt oder nicht stimmt ist das nicht so schlimm. In diesem Fall kann es geändert werden. Dein EAM Tool wird nie fertig sein. Jede Information soll nur an einem Ort gepflegt werden - Prinzip: keine Redundante Datenhaltung (bzw. Datenpflege)
4	Welche Informationssysteme / Datenbanken enthalten besonders wertvolle Information für EAM?	Produkte(z.B: Bodendaten) aus ERP(SAP) - Excelschnittstelle Applikationen werden an CMDB übergeben -Excelschnitstelle Prozessmanagementtool Der Preis für eine automatisierte Schnittstelle muss gerechtfertigt sein durch eine entsprechende Einsparung im Pflegeaufwand.

ID	Question German	Notes
5	Wie werden die die Informationen gesammelt? Wie werden die EAM Artefakte aktuell gehalten? (Wie oft?)	1 Applikationsowner von ADOit ist verantwortlich um Informationen "einzutreiben" Bei Änderung / Pflege sind Datenowner in der Pflicht (Schulungen notwendig) Ersterfassung: zentralistischer Ansatz Bei Änderungen / Instandhaltung: föderalistischer Ansatz
6	Was löst die Informationssammlung aus? (Events, Triggers)	Bestehende: Projektablaufeinbindung (siehe oben), Changeprozess im Betrieb (zwingende Nachführung) Pflegeprozess ist modeliert aber noch nicht eingeführt (Schulung noch notwendig) Prozesssteuerung geplant Unwissen über das Vorhanden sein von Systemen mit Potential für automasierte Triggers.
7	Was sind mögliche Probleme bei komplett manueller Datenerhebung?	Extrem hoher Zeitaufwand Vortwährende Diskussion "Was ist eine Applikation" (Buch: IT-Architektur) Homogenität der Datenbasis muss homogen bleiben, was keine einfache Aufgabe ist. Daher existieren Modelierungsprinzipien (gleiche Massstäbe). Die Pflege ist aber Fall- & Problemangepasst. "Architektur soll ermöglichen & nicht verhindern"
8	Gibt es konkrete Implementationen einer automatisierten Schnittstelle zwischen einem EAM-Tool und einer anderen spezifischen Datenabank? Wenn ja: Wie funktioniert der Datenabgleich? (XML, EXCEL, relDB, CSV, SOAP, REST) Was waren die Gründe eine Schnittstelle zu bauen? Wenn nein: Planen Sie eine automatisierte Schnittstelle zu implementieren? Welche möglichen Herausforderungen sehen Sie dabei?	Bewusste Abhängigkeit zur Fröderung der Konsistenz zwischen verschiedenen Applikationen. Schnittstelle Kosten: Seite EAM 5AT (Req spezifizieren, Umsetzung durch Hersteller, Testing) - insgesamt 7 AT Ein Ablgeich dauerte ungefähr 3 Stunden, die automatisierung der Schnittstelle hat sich also nach ca. 13 Abgleichen gelohnt. Abgleich geschieht bei Notwendigkeit. (--> Mail)
9	Wie wird der Erfolg von EAM gemessen?	Projektziel war nicht benötigte Redundanzen zu reduzieren. Was könnte man einsparen? Zu Beginn kostet EAM vorallem und der Nutzen ist schwer quantifizierbar. Exemplarisch kann muss relativ früh in einem Projekt aufgezeigt werden, was Architektur gebracht hat und und dies quantifizieren. Eigenmessung wird nicht betrieben, keine KPIs. Maturität noch nicht genug hoch. Könnte teilweise sinvoll sein. Bevor EA Informationen vorhanden waren, gab die Beschaffung der Informationen zu kundenrelevanten Produkten die mit Skripts generiert werden ca. 1 PT Aufwand pro Aufwand.
10	Welchen Einfluss hat die Qualität von EAM Artefakten auf den Erfolg?	-

Table A-1: Notes from interview with participant 1

A.2 PARTICIPANT 2

ID	Question German	Notes
1	Welche Informationen werden von EAM (UAM) benötigt? (Welche Funktionen werden in Ihrer Unternehmung durch EAM erfüllt?)	Anwendungen (1200), Schnittstellen(5000), Technologien, Platformen (TStack) Geschäftsprozesse (als BPMN modeliert aber nicht konzernweit), Geschäftsfähigkeiten (konzerneweit), Datenmodell (unternehmensweit, ist zentral Objekt) OrgEinheiten, Projekt, Produkt, IT-Bedarf (Projektgründe), Domäne
2	Welche Artefakte bringt EAM hervor? Wie werden die gesammelten Informationen von EAM dokumentiert?	Datenmodel, Repository (Publikation),Bebauungsplan (Neu, Abgelöst, Modifiziert,...), Geschäftslandkarte, Anwendungsdokumentation (Kontext), Prinzipien / Richtlinien / Ausnahmen (RequestFor Architecture), Domänenlandkarte, Heatmaps (Erklärung für Business, Planungsstand, Finanzielle Sicht), Geschäftsbedarf Abstufungen zu was gepflegt wird. Mit generierte Grafiken ist man ziemlich schnell am Anschlag, da man mit einer Grafik immer etwas Storytelling betreiben will und dies zwangsweise einen gewissen manuellen Aufwand benötigt. Grundlegende Grafiken können automatisch generiert werden aber es braucht zwangsweise einen manuellen Aufwand um die Grafik fertigzustellen.
3	Woher stammen EAM relevante Informationen?	Aus Systemen importiert und Relationen in EA Tool gepflegt **Richtlinien** müssen (in Zusammenarbeit mit der Architektur) von den Personen geschrieben werden, welche Sie im Endeffekt auch einhalten müssen. Es bringt nichts wenn die Architektur Richtlinien vorgiebt, welche dann nicht eingehaltet werden / werden können. Eine Sorte von Richtlinie sind **Prinzipien,** welche die Architektur pflegt und aktuell haltet.
4	Welche Informationssysteme / Datenbanken enthalten besonders wertvolle Information für EAM?	Anlieferer: ICT PPMDB Projektportfolio (Datenbank, bidirektionale Sst), SAP ERP(IT-Produkte), SAP HCM (Org Einheiten), Prozessplatform, Beliefert: ITSM (CMDB), Produktportal, EMoD (IT Betrieb), Servicedesk (Vertraut auf hohe Datenqualität) Keine Integration mit Softwareentwicklung, EA als Modelierungswerkzeug (Dialog von Unternehmensarchitekt mit Softwarearchitekt im Vordergrund, Daten werden manuell erhoben)
5	Wie werden die die Informationen gesammelt? Wie werden die EAM Artefakte aktuell gehalten? (Wie oft?)	Architekt muss vor Ort gehen (vorallem bei Projekten) Zwang zur Dokumentation: Einbindung in Projektlebenszyklus (bei Betriebsübergabe) müssen die Projektleiter Architekturartefakte nachdokumentieren - funktioniert nicht gut da Interessenlage für Projektleiter nicht gegeben Das Meiste ist Wochenaktuell (good enough), ganz weniges ist täglich (bidirektionale Sst PPMDB) Architekten dokumentieren Hauptobjekte selber. Zentralistischer Ansatz. Die Architekten erhalten explizit Zeit für die Dokumentation.
6	Was löst die Informationssammlung aus? (Events, Triggers)	Prozess: Request for Architecture - Überwachen der Einhaltung von Prinzipien & Richtlinien sowie Erteilung von Ausnahmen (involviert sind Relevante Entscheidungsträger in der IT) Prozess: Bebauungsplanung - Entwicklung der IT wird dokumentiert und geplant. Interne (Technologieänderungen) und externe (Geschäftsveränderungen) Einflüsse lösen diesen Prozess aus. Faktor für die Qualität: Dokumentationverpflichtung von Architekten - Architekten erhalten explizit Zeit um zu Dokumentieren Faktor für die Qualität: Die Architekturartefakte müssen in verschiedenen operativen Prozessen genutzt werden. So wird aufgedeckt welche Artefakte nicht genügen Qualität aufweisen und diese werden dann aktiv bewirtschaftet. Die Erfahrung zeigt, dass in operative Prozesse eingebundene Artefakte generell eine höhere Qualität aufweisen als Artefakte die ausschlisslich nachdokumentiert werden. Triggers / Events: Finanzplanungsprozess benötigt abgeschlossener Bebauungsplanprozess, bei Projektkreditantrag muss eine Architekturbeurteilung vorhanden sein. Domänenreifegradreporting liefert den Architekten informationen was geführt werden muss. Es wird eine Issueliste geführt woraus Tasks abgeleitet werden über Artefakte die überarbeitet werden müssen. Themenfokusierte Überprüfung in einer Periode. Zum Beispiel im ersten halben Jahr 2015 überprüfen wir alle fachlichen Beschreibungen von Objekten. Schlechte Artefakte auch entfernen ("Scheiden tut weh") anstatt grundlos weiterzuführen ("Weniger ist mehr").

ID	Question German	Notes
7	Was sind mögliche Probleme bei komplett manueller Datenerhebung?	Nutzen für Dokumentierende muss gegeben sein.
8	Gibt es konkrete Implementationen einer automatisierten Schnittstelle zwischen einem EAM-Tool und einer anderen spezifischen Datenabank? Wenn ja: Wie funktioniert der Datenabgleich? (XML, EXCEL, relDB, CSV, SOAP, REST) Was waren die Gründe eine Schnittstelle zu bauen? Wenn nein: Planen Sie eine automatisierte Schnittstelle zu implementieren? Welche möglichen Herausforderungen sehen Sie dabei?	EAM Datenbank hat die Stärke, dass Informationen aus verschiedenen ebenen mit einander verknüpft werden. Die Verbindungen sind vorallem die relevanten Elemente die von Architekten gepflegt werden müssen. Die Objekte / Klassen selber werden an anderen Orten gepflegt. Konzeptunterschied: Informations- / Datenfluss versus Serviceangebot Servicenutzung. Diese Konzepte haben eine andere Zielsetzung bzw. einen anderen Nutzen. Excelbasierte Schnittstellen. Möglichst einfach gehalten. Haupthinderniss: Modelunterschiede, wie erreicht mein die EAM Flughöhe.
9	Wie wird der Erfolg von EAM gemessen?	Wirkungsorientierung ist extrem schwierig für eine Querschnittsfunktion wie EAM. Anzahl Anwendungen (Soll nicht wachsen): Eine der zentralen Messgrössen ist die Anzahl Anwendungen, die nicht wachsen soll. Wenn möglich soll nicht etwas neues gebaut / gekauft werden sondern etwas bestehendes wiederverwendet werden. Wenn nicht möglich soll etwas neues immer etwas bestehendes ersetzen. Standardisierungs-KPI: Eine weitere Messgrösse ist der Anteil an Standardprodukten die verwendet werden (Buy before Make). Mehrwert durch Transparenz steht am Anfang. Zentral ist die Dokumentation der Architektur, aber es benötigt ebenso Prozesse wie diese Dokumentation entsteht und wie sie verwendet wird.
10	Welchen Einfluss hat die Qualität von EAM Artefakten auf den Erfolg?	Wichtig! Schlechte Qualität bekommt man sehr schnell und ist sehr schädlich. Möglichst wenig dokumentieren, dafür was man dokumentiert muss überwacht werden. Prinzip Skepsis. Man versucht eingeführte Attribute die nicht genutzt oder nicht sauber dokumentiert werden auch wieder zu entfernen. Es gibt viele Ideen im Unternehmen wie auch in der Literatur welche Attribute zusätzlich gepflegt werden können. Aber es muss in jedem Fall konkret aufgezeigt werden, wie etwas genutzt (Unterstützung Prozesse, Unterstützung Entscheide) und wie etwas gepflegt (Aufwand für initiale Erfassung und kontinuirliche Pflege , Prozess der Pflege) wird bevor die Attribute erfasst werden. Automatisierte Imports oder Pflege basiert aber immer auf der Datenqualität des Quellsystems, welche auch analysiert werden muss. Qualitäts-KPIs: Domänenreifegrad: Wie gut ist eine Anwendung dokumentiert? (Attribute / Relationen werden abgefragt ob sie ausgefüllt sind oder nicht) Ziel ist kontinuirliche Verbesserung der Qualität. Integrierung von Dokumentationsaufgaben in Zielvereinbarungen der Architekten
-	Non quesiton related statements	"Wir haben nicht nur das Werkzeug eingeführt, sondern immer das Werkzeug mit Methode (mit konkretem Leitfaden). Wir entwickeln unsere Kulter auch in die Richtung, dass die Methodik in einem kollaborativen Ansatz diskutiert und verbessert wird." Wird momentan gemacht: Prozess --> Applikationen Ist angedacht aber extremer Pflegeaufwand: Prozess --> Prozessschritte --> Funktionalität (2000-3000) --> Applikation Was in der Praxis funktioniert. Pragmatischer Approach: Schritt für Schritt. Etwas implementieren, analysieren wie es funktioniert, pflegen und Datenqualität steigern. Dann etwas neues Angehen. Ansonsten ertrinkt man in der Menge der Information.

Table A-2: Notes from interview with participant 2

A.3 PARTICIPANT 3

ID	Question German	Notes
1	Welche Informationen werden von EAM (UAM) benötigt? (Welche Funktionen werden in Ihrer Unternehmung durch EAM erfüllt?)	Technologieschicht: Technologien, Roadmaps der Technologien, Serverlandschaft Applikationsschicht: Applikationsgesundheit, Menge, Kosten, Incidents, Lifecycle, Schwierigkeiten, Eigenentwicklungen, Abhängigkeiten Konzernschicht: Bebauungsplanung, Redundante Applikationen, Funktionalitäten / Capabilities
2	Welche Artefakte bringt EAM hervor? Wie werden die gesammelten Informationen von EAM dokumentiert?	5 Säulen des EAMs: Transparenz(Ist-Zustand), Planung, Vorgaben(Prinzipien), Methodik (Tools) Ist-Landkarte (eher unwichtig bzw. nur wenig Zeit soll darauf gelegt werden, Erfassung soll automatisch geschehen), Planungs- und Zielbilder, Objekte im Modell, Reports & Analysen, Bebauungspläne, Roadmaps, Business Continuity Management: wo müssen Server / Applikationen verstärkt werden.
3	Woher stammen EAM relevante Informationen?	Moment passiert EAM in einem Exceltool welche an verschiedene andere Systeme angebunden ist. Informationen stammen aus Tools, welche durch Verantwortliche gepflegt werden. Ein zukünftiges EAM Tool soll umfänglich aus SlaveDaten bestehen damit der Pflegeaufwand klein bleibt. EAM Tool sollte SinglePoint of Truth sein. Dies bedeutet aber nicht unbedingt, dass das EAM Tool Master bei allen Objekten ist.
4	Welche Informationssysteme / Datenbanken enthalten besonders wertvolle Information für EAM?	Servicemanagement (eigentliches Produkt mit SLA): Alle Dienstleistungen von Applikationen werden in fachliche Services gebündelt und dem Kunden verkauft. Dies basiert auf einem zweiten Metamodel, welches eine kommerzielle Sicht darstellt. Und diese Servicedatenbank ist auch an andrere Systeme angebunden. QMS (Qualitätsmanagementssystem) enthält Prozesse. Personendatensystem CMDB ServicemanagementDB (eigentliches Produkt mit SLA)
5	Wie werden die die Informationen gesammelt? Wie werden die EAM Artefakte aktuell gehalten? (Wie oft?)	Möglichst viel automatisierte Imports mit möglichst wenig Pflegeaufwand für die Architekten (reines Slavetool). Föderalistischer Ansatz mit Architekturcommunity.
6	Was löst die Informationssammlung aus? (Events, Triggers)	Projektlebenszyklus (Nutzen für Projektleiter ist der im nächsten Projekt gesparte Aufwand für die Informationssammlungs) Am Start des Projekts wird über die achitekturrelevanz. **Prinzipien** sind wichtig aber es darf nicht zu viele haben. Man muss sich die Prinzipien einfach merken können. Es muss auch überprüft werden können wie die Prinzipien greifen. Es ist auch kritisch zu hinterfragen, ob gewisse Prinzipien über die Zeit noch aktuell sind bzw. noch benötigt werden oder ob sie verstärkt werden müssen.
7	Was sind mögliche Probleme bei komplett manueller Datenerhebung?	-
8	Gibt es konkrete Implementationen einer automatisierten Schnittstelle zwischen einem EAM-Tool und einer anderen spezifischen Datenabank? Wenn ja: Wie funktioniert der Datenabgleich? (XML, EXCEL, relDB, CSV, SOAP, REST) Was waren die Gründe eine Schnittstelle zu bauen? Wenn nein: Planen Sie eine automatisierte Schnittstelle zu implementieren? Welche möglichen Herausforderungen sehen Sie dabei?	Wunsch auf BiDirektionale Schnittstellen weil Excel-Schnittstellen quasi antiquitiert sind. Auf der anderen Seite werden produktive IT-Systeme angebunden und meist ist der einfachste und schnellste Weg oft eine Excel Schnittstelle. Die Schnittstellen können sich ja über die Zeit weiterentwickeln. Die Frage ist auch was eine Tagesaktualität. Es genügt eigentlich die Daten nur periodisch, also höchstens wöchentlich zu aktualisieren.

ID	Question German	Notes
9	Wie wird der Erfolg von EAM gemessen?	Es existieren bzw. es sind noch keine KPIs definiert, welche den Erfolg von EAM messbar machen. Es ist aber deutlich, dass EAM in Zukunft benötigt wird um konkrete Aussagen über die momentan sehr komplexe IT-Landschaft machen zu können. Es gibt viele Applikationen und Technologien die schon seit längerem im Einsatz sind und es brauch konkrete Entscheidungsgrundlagen auf deren Basis solche Systeme ersetzt oder weiterentwickelt werden können. Steuerbarkeit & Transparenz schaffen. Servicedesk hat schnell Zugriff auf relevante Daten und kann so schneller Fragen beantworten. Architekten sollen möglichst schnell Nutzen erbringen in der Form von Zielbildern und Entscheidungsgrundlagen und nicht sich mit Dokumentation des IST-Zustands beschäftigen (wobei dieser für die Erstellung der Zielbilder benötigt wird). Auf der einen Seite ist es wichtig für EAM den obersten Layer zu integrieren um die Analysen auch Managementrelevant zu gestalten. Wenn man von oben nach unten arbeitet gibt es möglicherweise viel mehr Potential wie wenn man sich zu Beginn nur in den unteren Layers bewegt. Es gibt Querschnittsthemen die nicht abgedeckt sind mit den Silosichten der einzelnen Geschäftsbereichen. Eine aggregierte Gesamtsicht über sehr diverse Geschäftsfelder könnte sehr hohe Optimierungspotentiale aufzeigen. In vielen Firmen die nicht mit Waren handeln, sind die Daten die eigentlichen Assets der Firma. Die Daten werden aber nicht so wertgeschätzt wie wenn zum Beispiel bei einem Autohersteller ein Metalbauteil fehlt. Zukünftige Geschäftsmodelle werden immer mehr Daten als solches miteinbeziehen. Deswegen wächst die Wichtigkeit von unternehmensweiten Datenmodellen und von Übersichten über die Datenverteilung.
10	Welchen Einfluss hat die Qualität von EAM Artefakten auf den Erfolg?	Wichtig ist zu priorisieren wie tief / detailliert die Informationen benötigt werden? 2 Beispiele: Wieviel Debian Linux betreibene Server haben wir? Wie sieht der Arbeitsplatz der Zukunft aus? Zwei völlig unterschiedliche Fragestellungen die auch unterschiedliche Anforderungen an die Dokumentation des Ist-Zustandes stellen. (Thema Abstraktion) Die Qualität des IST-Zustands ist entscheidend um den Nutzen von EAM für verteilte Stakeholders sicherzustellen.

Table A-3: Notes from interview with participant 3

A.4 PARTICIPANT 4

ID	Question German	Notes
1	Welche Informationen werden von EAM (UAM) benötigt? (Welche Funktionen werden in Ihrer Unternehmung durch EAM erfüllt?)	Im Tool (MEGA) werden vorallem vier Hauptassets verwaltet. Diese sind Applikationen (>300), Techn. Komp., Geschäftsprozesse (>1300) und Informationsflüsse / IT Services. Desweiteren führen wir Assets wie Domänen, Personen & Org. Einheiten --> Verantwortlichkeiten (bringt hohen Nutzen), Projektauflage, Architekturexceptions, Technologielifecycle Issues, Run-& Change-Kosten APL & Technische Komponenten waren die ersten erfassten Assets
2	Welche Artefakte bringt EAM hervor? Wie werden die gesammelten Informationen von EAM dokumentiert?	Es wird relativ wenig modeliert. PDF Reports (pro Applikation, techn. Komponente, Prozesse) Excel / XML Exports für andere Applikationen: Coast Reporting, Service Management, Role Center, APM (Quality Assurance Process), Risk Management. Diese APL erhalten vorallem Information zu den APL und Techn.Komp. Serververwaltungstool wird auch beliefert Application Environment Diagram (pro Applikation, zeigt die Informationsflüsse zwischen den Applikationen, welche dann mit ein oder mehereren IT Services verknüpft werden können) Appl. Landscape Diagram Die Unique ID für Objekte (wie APL oder Tech.Komp) ist auch ein Key Asset
3	Woher stammen EAM relevante Informationen?	Ursprüngliche Erfassung durch Zentrale Architekten mithilfe von SMEs. Mittlerweile werden viele Information manuell nachgepflegt.

ID	Question German	Notes
4	Welche Informationssysteme / Datenbanken enthalten besonders wertvolle Information für EAM?	In CentraSite (Service Repo) werden Services dokumentiert und den Applikationen zugeordnet und diese Informationen werden wöchentlich wieder ins MEGA (EAM Tool) importiert. Die Überlegung war bewusst ein dediziertes Tool für Servicedesign zu haben, welches die ganzen Details zu den Services wie die Implementierung, die Datenstrukturen und weitere Details zu Services werden dort verwaltet. Kosten aus Kostenreporting (Eigenentwicklung) Momentan keine Projekte (da Pflegekonzept) aber es existiert ein Konzept wie zukünftig das Objekt Projekt zu nutzen. Dabei müssen aber die Beziehungen zu anderen Objekten auch in Betracht gezogen werden. Viele Architekturinformationen wird in Sharepoint verwaltet, wo auch Beziehungen genutzt werden. (z.B. Projektdashboard beinhaltet: Projektauflagen, Architekturausnahmen, Technologie-Lifecycleissues) "Mein neigt dazu Informationen zuerst zu importieren und sich erst dann zu überlegen, was man damit überhaupt erreichen möchte und auch wie sie und die mit Ihnen neu entstandnen Relationen gepflegt werden sollen."
5	Wie werden die die Informationen gesammelt? Wie werden die EAM Artefakte aktuell gehalten? (Wie oft?)	Die Datenpflege läuft über den Quality Assurance Prozess (des Technology Lifecycle Managements), welcher zwei mal jährlich durchlaufen wird. Dabei wird ein Status auf den Objekten im Repository gesetzt, der durch den Veranwtworlichen durch ein Review auf "Approved" gesetzt wird. Technische Komponenten werden durch Technische Architekten / Verantwortlichen für technische Komponenten geführt. Applikationsverwantwortliche pflegen die Applikationen und deren technischen Unterbau. IT Architekten identifizieren Techn. Komponenten die aus dem Lifecycle laufen und stossen Abklärungen für den Ersatz an. Die Pflege wird nach Verantwortlichkeit in MEGA gesteuert und passiert in einem föderalistischen Prozess. Daneben wird Datenpflege auch während einem Projekt betrieben.
6	Was löst die Informationssammlung aus? (Events, Triggers)	Gates im Projekt: Vor Inbetriebnahme (bei grösseren auch vor dem Detailkonzept) muss dokumentiert werden (auch im EAM tool). Diese Art von Dokumentation ist aber schwierig Toolmässig oder Prozessmässig effektiv abzufangen. Darum ist es wichtig, dass die Projektleiter darauf geschult werden. Bindungen: Im TicketingSystem muss eine APL ID gelöst sein. Changeverwaltungstool (E-Change) braucht APL ID. 2 mal im Jahr Aufruf über Webclient mit 2 Wochenfrist. Review Status auf Objekten. Workflow Enginge wurde aus Kostengründen weggelassen.
7	Was sind mögliche Probleme bei komplett manueller Datenerhebung?	Aufwand für Review ca. 15 Minuten pro APL oder techn. Komp. Zum Teil gibt es das Problem das der jeweilige Applikationsverantwortliche nicht genügend über die technischen Komponentne wissen und somit Mehraufwand oder Falscherfassungen entstehen.
8	Gibt es konkrete Implementationen einer automatisierten Schnittstelle zwischen einem EAM-Tool und einer anderen spezifischen Datenabank? Wenn ja: Wie funktioniert der Datenabgleich? (XML, EXCEL, relDB, CSV, SOAP, REST) Was waren die Gründe eine Schnittstelle zu bauen? Wenn nein: Planen Sie eine automatisierte Schnittstelle zu implementieren? Welche möglichen Herausforderungen sehen Sie dabei?	Im Einsatz ist ein selbst entwickeltes Tool mit der Information mit Applikation, Technologiekomponente & Serverinstanz. Die Anbindung wurde aber depriorisiert weil diese Information womöglich zu feingranular vorhanden sind für eine automatische Anbindung. Darum ist eine manuelle Instand momentan noch "good enough". "Trigger Based EAM": Ja das könnte man sich absolut vorstellen. Die Herausforderung wird sein die richtigen Trigger zu finden. Wo setze ich die Pointer. Man muss unterscheiden zwischen externen Triggern und was intern abgefangen werden kann. Bei gewissen Tools gibt es durchaus Möglichkeiten um Notifications auszulösen wenn an einem bestimmten Objekt etwas geändert wird. Zeitpunktvergleich: was hat sich seit letzem Import verändert?

ID	Question German	Notes
9	Wie wird der Erfolg von EAM gemessen?	Man kann nicht einfach irgendeinen Case rechnen. Durch strukturierte Dokumentation der Unternehmensarchitektur, spart man einfach einen Haufen Zeit. Die Erfolge verteilen sich in der ganzen Unternehmung. Es ist jedermann verständlich, dass wenn man Informationen sauber strukturiert, dass dies dem Unternehmen etwas bringt, leider nur schwer quantifiziertbar. Es ist unbestritten, dass auch bei Grossprojekten durch Bereitstellung der IST-Dokumentation in hoher Qualität viel sparen kann, doch leider diese Einsparung unmöglich quantifizierbar. Wir haben versucht für einzelne Domänen KPIs zu definieren. z.B. Anzahl Applikationen pro Domäne. Aber wieviele sind denn sinnvoll. Manchmal ist es vorteilhaft mehrere Applikationen mit ähnlicher Funktionalität einzusetzen. Dies ist nur im Einzelfall klar beurteilbar. Aber was die Architektur klar bringt ist diese Einzelfälle aufzuzeigen und zeigt daher Optimierungspotential auf. Architektur mach Dinge sichtbar / transparent die man ohne gar nicht entdecken würde. In Zukunft wollen wir Run & Change Kosten der Applikation auf der Applikationslandkarte verwenden und dadurch aufzuzeigen, welche Domänen bzw. Geschäftsfunktionalitäten wie viel kosten? (Birgt auch gewisses Gefahrenpotential da Applikationen meist in mehreren Domänen verwendet wird) Das gedenken wir auch für die Prozesse zu machen.
10	Welchen Einfluss hat die Qualität von EAM Artefakten auf den Erfolg? Wie wird Qualität gemessen?	Es existieren auswertbare Modelierungsregeln (auch eine politische Diskussion). Mit diesen Regeln kann eine Aussage über den Dokumentationsgrad der Applikationen gemacht werden. Dabei gibt es pro Applikation auch eine Anzahl Errors welche an das Management gespielt werden kann. Andererseits werden qualitative Stichprobenkontrollen der Objekte durchgeführt (Ressourcenproblem). Der Nutzen dabei ist eine höhere Verlässlichkeit auf die Daten zu gewinnen, was automatisch den Erfolg von EAM verstärken sollte.

Table A-4: Notes from interview with participant 4

Appendix B – The Data Source Selection Catalogue for EA Documentation

B.1 COVERAGE MATRIX

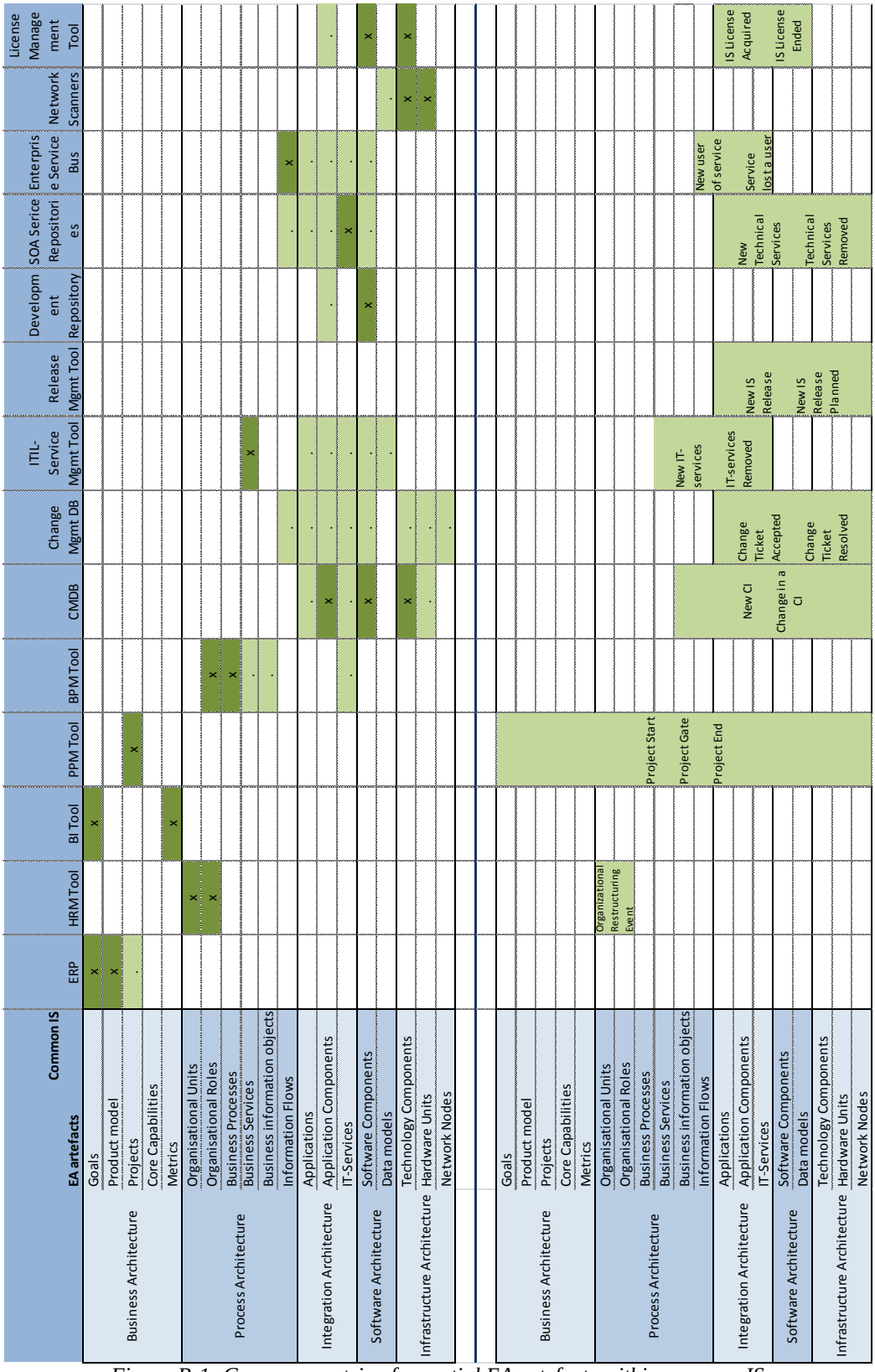


Figure B-1: Coverage matrix of essential EA artefacts within common IS

B.2 EVALUATION CATALOGUE WITH EXAMPLE

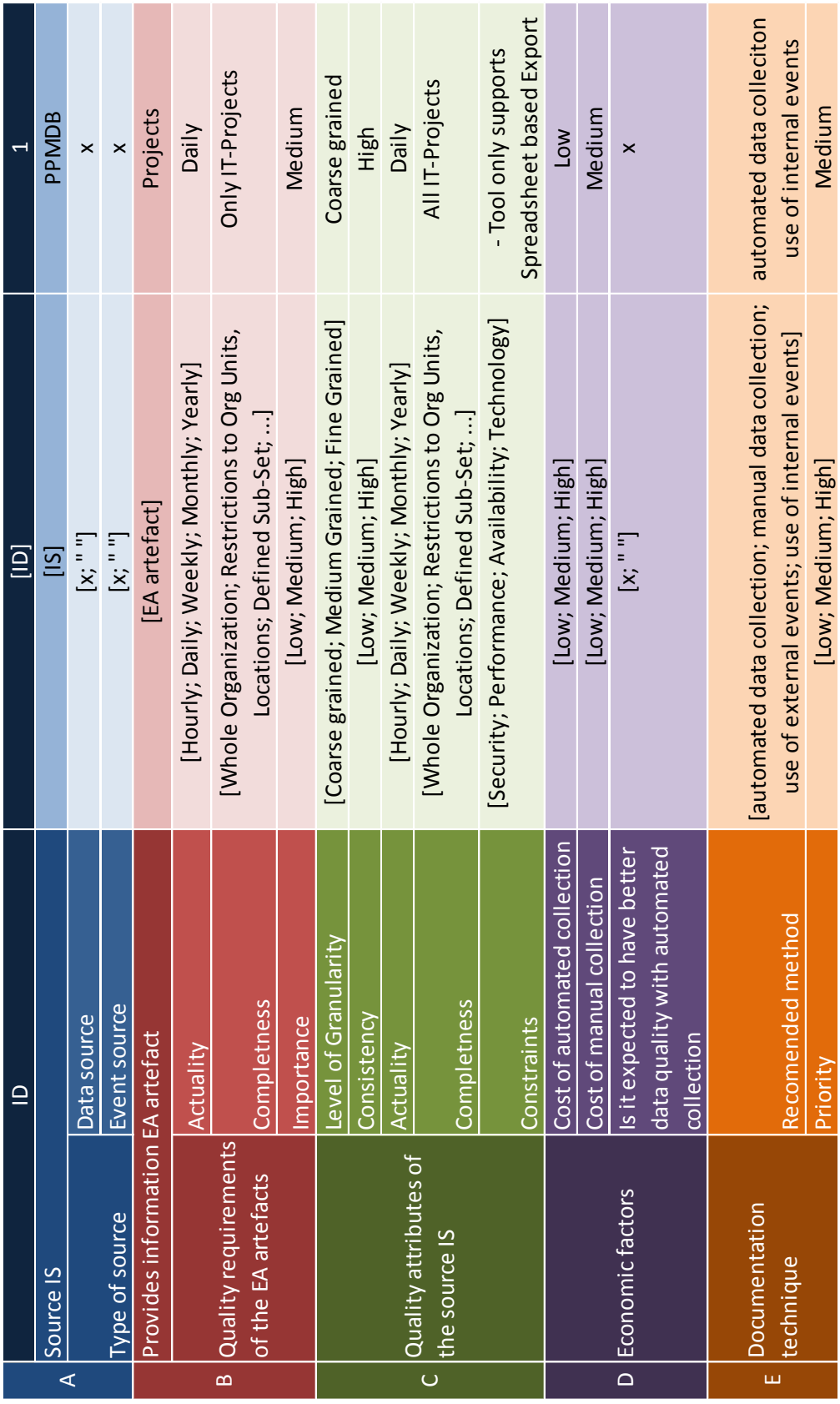
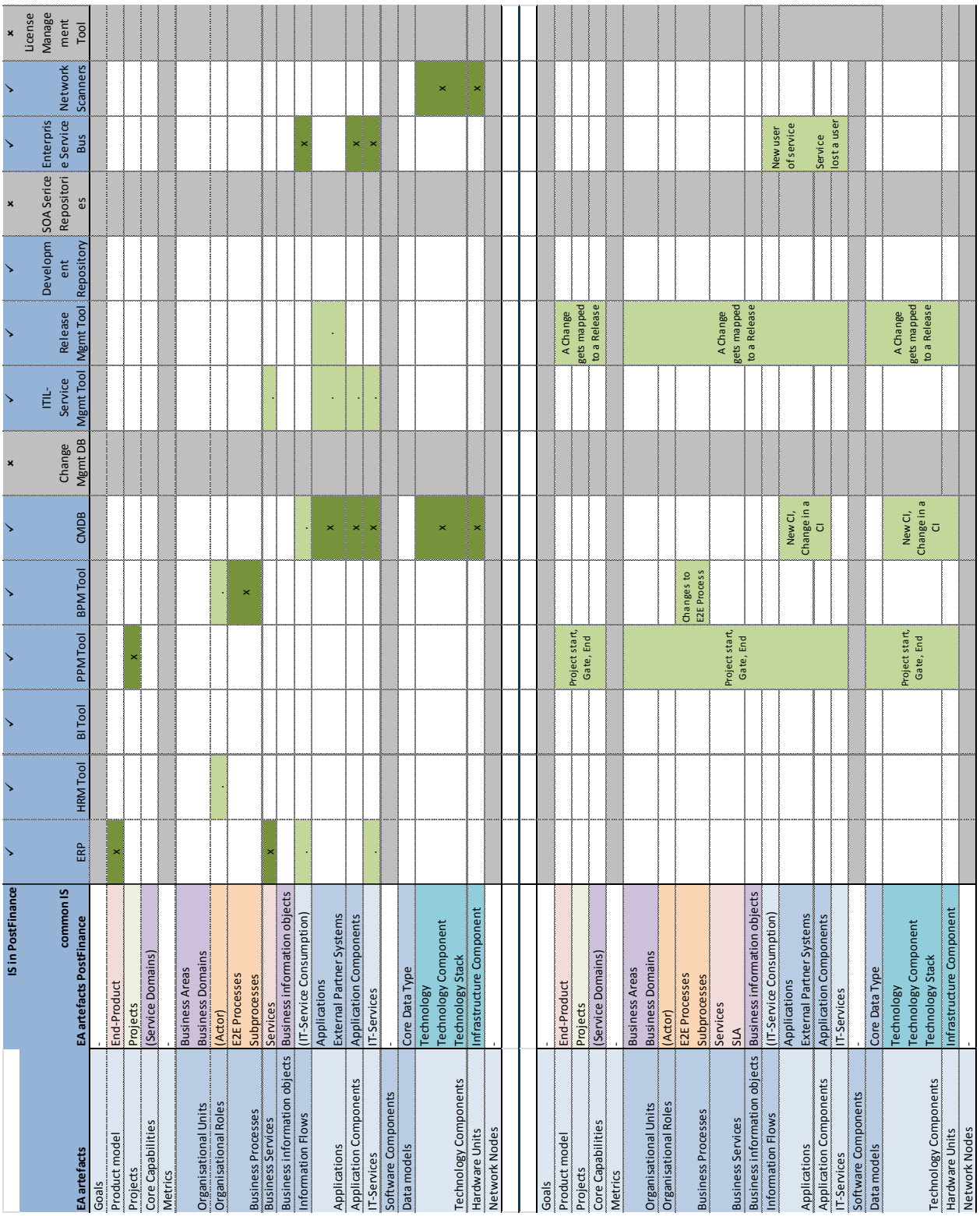


Figure B-2: Evaluation catalogue for potential EA documentation sources with example

Appendix C – Application of the catalogue at PostFinance

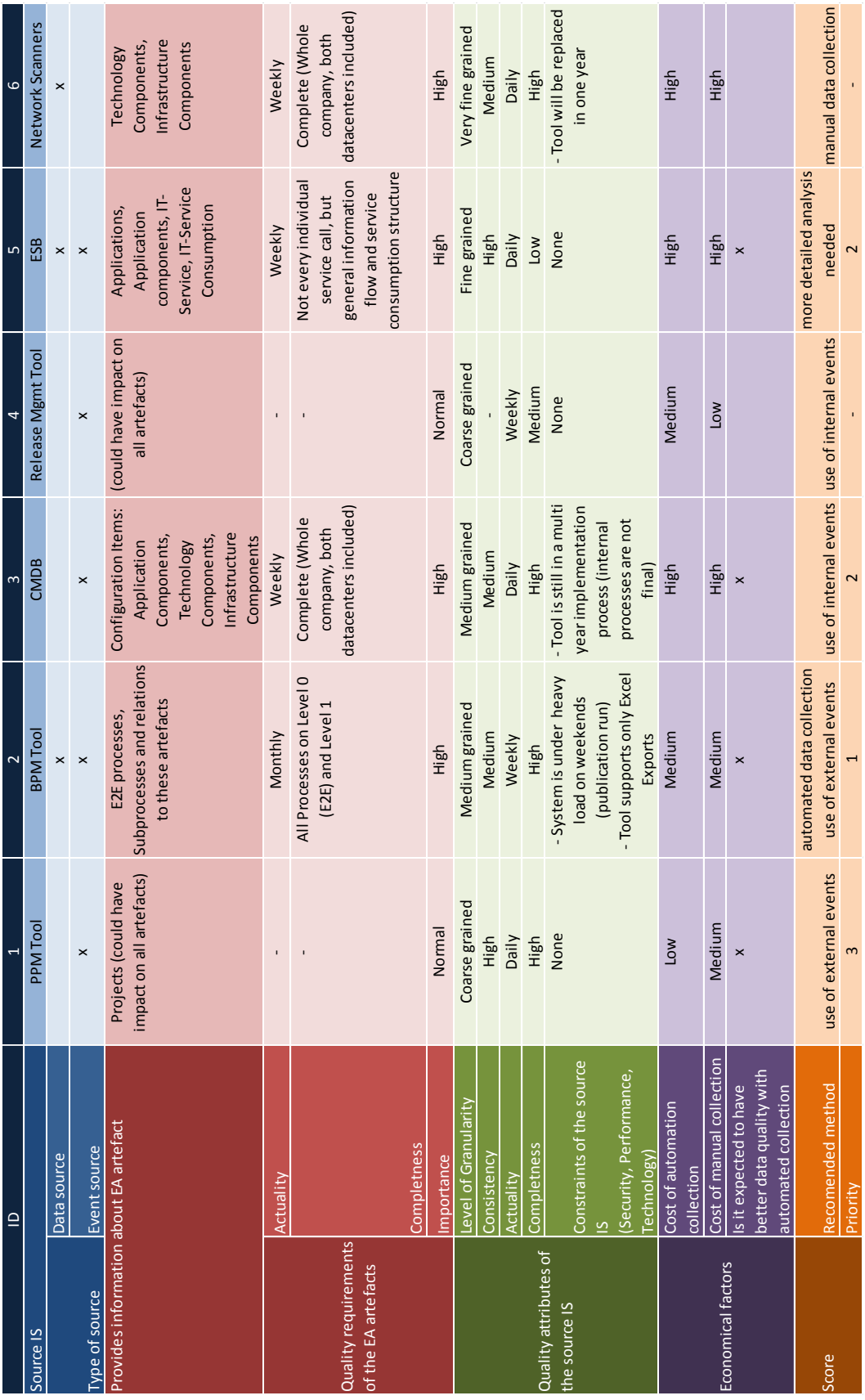
C.1 COVERAGE MATRIX



EA artefacts	IS in PostFinance: EA artefacts PostFinance	✓ ERP	✓ HRM Tool	✓ BI Tool	✓ PPM Tool	✓ BPM Tool	✓ CMDB	× Change Mgmt DB	✓ ITIL-Service Mgmt Tool	✓ Release Mgmt Tool	✓ Development Repository	× SOA Serice Repositories	✓ Enterprise Service Bus	✓ Network Scanners	× License Management Tool
Goals	-														
Product model	End-Product	x													
Projects	Projects				x										
Core Capabilities	(Service Domains)														
Metrics	-														
Organisational Units	Business Areas														
	Business Domains														
Organisational Roles	(Actor)		.			.									
Business Processes	E2E Processes														
	Subprocesses					x									
Business Services	Services	x							.						
Business information objects	Business information objects														
Information Flows	(IT-Service Consumption)	.					.						x		
Applications	Applications						x		.	.					
	External Partner Systems														
Application Components	Application Components						x		.				x		
IT-Services	IT-Services	.					x		.				x		
Software Components	-														
Data models	Core Data Type														
Technology Components	Technology													x	
	Technology Component						x								
	Technology Stack														
Hardware Units	Infrastructure Component						x							x	
Network Nodes	-														
Goals	-														
Product model	End-Product									A Change gets mapped to a Release					
Projects	Projects				Project start, Gate, End										
Core Capabilities	(Service Domains)														
Metrics	-														
Organisational Units	Business Areas														
	Business Domains														
Organisational Roles	(Actor)														
Business Processes	E2E Processes					Changes to E2E Process									
	Subprocesses														
Business Services	Services				Project start, Gate, End					A Change gets mapped to a Release					
	SLA														
Business information objects	Business information objects														
Information Flows	(IT-Service Consumption)												New user of service		
Applications	Applications						New CI, Change in a CI								
	External Partner Systems												Service lost a user		
Application Components	Application Components														
IT-Services	IT-Services														
Software Components	-														
Data models	Core Data Type														
Technology Components	Technology														
	Technology Component				Project start, Gate, End		New CI, Change in a CI			A Change gets mapped to a Release					
	Technology Stack														
Hardware Units	Infrastructure Component														
Network Nodes	-														

Figure C-1: Application of coverage matrix at PostFinance

C.2 EVALUATION CATALOGUE



ID		1	2	3	4	5	6
Source IS	Data source	PPM Tool	BPM Tool	CMDB	Release Mgmt Tool	ESB	Network Scanners
			x			x	x
Type of source	Event source	x	x	x	x	x	
Provides information about EA artefact		Projects (could have impact on all artefacts)	E2E processes, Subprocesses and relations to these artefacts	Configuration Items: Application Components, Technology Components, Infrastructure Components	(could have impact on all artefacts)	Applications, Application components, IT-Service, IT-Service Consumption	Technology Components, Infrastructure Components
Quality requirements of the EA artefacts	Actuality	-	Monthly	Weekly	-	Weekly	Weekly
	Completness	-	All Processes on Level 0 (E2E) and Level 1	Complete (Whole company, both datacenters included)	-	Not every individual service call, but general information flow and service consumption structure	Complete (Whole company, both datacenters included)
	Importance	Normal	High	High	Normal	High	High
Quality attributes of the source IS	Level of Granularity	Coarse grained	Medium grained	Medium grained	Coarse grained	Fine grained	Very fine grained
	Consistency	High	Medium	Medium	-	High	Medium
	Actuality	Daily	Weekly	Daily	Weekly	Daily	Daily
	Completness	High	High	High	Medium	Low	High
	Constraints of the source IS (Security, Performance, Technology)	None	- System is under heavy load on weekends (publication run) - Tool supports only Excel Exports	- Tool is still in a multi year implementation process (internal processes are not final)	None	None	- Tool will be replaced in one year
Economical factors	Cost of automation collection	Low	Medium	High	Medium	High	High
	Cost of manual collection	Medium	Medium	High	Low	High	High
	Is it expected to have better data quality with automated collection	x	x	x		x	
Score	Recomended method	use of external events	automated data collection use of external events	use of internal events	use of internal events	more detailed analysis needed	manual data collection
	Priority	3	1	2	-	2	-

Figure C-2: Application of evaluation catalogue at PostFinance