Utrecht University

July 2019
Version 1.0

Tailoring a Domain-Specific Enterprise Architecture Maturity Model

Master Business Informatics Graduation Project – Thesis

Author:
Mart van Zwienen
Student number: 6212670

First supervisor:
Dr. Marcela Ruiz

Second supervisor:
Dr. Verónica Burriel

External supervisor:
Dr. Ir. Marlies van Steenbergen

Acknowledgements

The research I conducted the past eight months are the crown on the master of Business Informatics, the thesis in front of you is the result. Perhaps the jewel on top of the crown is the paper about a part of the thesis which got accepted at the international working conference on exploring modelling methods for systems analysis and development. The crown with the jewel on top all came together with the help of many people. I would like to thank all of them.

First and foremost, I would like to thank Marcela Ruiz for providing valuable feedback, creative suggestions, and supervision. But also, for the amazing time in Rome at the conference. Especially your enthusiasm has brought a lot of fun to the past eight months, thank you for that.

Someone who has always stood by my side during this research was Marlies van Steenbergen. It was most helpful to have you as a sparring partner during the research. Your creative insights and critical thinking helped bring the research to the next level.

The paper came together with the help and input of both of you, and that of Verónica Burriel. Thank you for providing your suggestions for the paper as well. Your input and feedback throughout this research showed to be most valuable.

Without the help of professionals in practice, none of this research would have been possible. I did some calculations, and although without crossing doubles, a staggering number of 95 experts with accumulated 1281 years of experience helped in this research. In special I would like to thank the professionals of the architecture community healthcare of the Dutch government, the colleagues at Sogeti, and all the participants from the case studies of the hospitals.

Abstract

Healthcare organisations lag behind on utilising information technology. Enterprise architecture can provide these increasingly complex organisations with appropriate data structures, information systems, and infrastructure to ensure agility, consistency, compliance, and efficiency. The effectiveness of the enterprise architecture is often expressed as the level of maturity. Several models have been introduced to measure and improve the enterprise architecture maturity of organisations. However, there is none yet for hospitals. There also lies an opportunity to enrich enterprise architecture maturity models with reference architectures. Therefore, this research comprises the design of an enterprise architecture maturity model for hospitals with the help of a reference architecture. We conducted a systematic literature review to establish the state-of-the-art of enterprise architecture maturity models. From these existing models, we selected one to tailor it towards hospitals with the help of a reference architecture. We successfully integrated parts of the reference architecture in the existing model by metamodeling both models and finding components which have overlap in the dimension of enterprise architecture they focus on. This first initial design was subject for the first validation. With two focus group sessions we validated the design and improved the design, the first concerned the semantics of the design whereas the second comprised the syntax of the design. After these two focus group sessions, some parts were still unclear and needed further improvement and validation. Therefore, we organised an expert interview and think aloud sessions. With this extra validation we concluded the design of the model. By conducting a multiple-case study research we then validated the model itself in the context of Dutch hospitals. In total, we conducted case studies at seven hospitals. The results show that the architects of the hospitals have positive attitudes towards the intention to use, perceived usefulness, and the perceived ease of use of the enterprise architecture maturity model for hospitals. Additional interviews strengthen these results and provided more insight into their perceptions. These interviews also revealed some weaknesses of the working method, leaving room for future improvements.

Table of Contents

List of figures

List of tables

1. Introduction

This chapter is an introduction to this research. We present the motivation, together with some background on the subject. This motivation leads to a gap in research and an opportunity in practice, this gap can be filled by answering the research questions presented in subchapter 1.1.1. How these questions are answered is explained with a research approach. Finally, we present the thesis outline.

1.1 Motivation

There lies a major opportunity for improving quality in health by increasing the use of information technology (Bates, 2002). Providing reliable, efficient, and individualised care requires a degree of mastery of data and coordination that will be achievable only with the increased use of information technology (Bates & Gawande, 2003). However, there is a level of complexity in the healthcare domain, which stems from a variety of interdependencies and many specialisations with their own processes, technology, and data requirements (Gebre-Mariam & Bygstad, 2016). It has been difficult to cope with this complexity, reports suggest that healthcare organisations lag behind on other organisations in utilising information technology (Gandhi, Khanna, & Ramaswamy, 2016; Romanow, Cho, & Straub, 2012).

Healthcare organisations are therefore exemplary types of organisations that can benefit from enterprise architecture (Ajer, 2018). Enterprise architecture provides appropriate data structures, information systems, and infrastructure in order to ensure agility and consistency, compliance and efficiency for the increasingly complex organisations (Nikpay, Ahmad, Rouhani, & Shamshirband, 2016; Winter & Fischer, 2006).

The effectiveness of the organisation's enterprise architecture is often expressed in the maturity of the enterprise architecture. With the enterprise architecture, we consider "the coherent whole of the principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business processes, information systems, and infrastructure" as described by Lankhorst (2017, p. 3). How one manages this coherent whole is what we call the enterprise architecture function or management. One can also speak of the enterprise architecture as a product, which are the actual models that represent the business processes, information systems, and infrastructure of an organisation. When we speak of the product of enterprise architecture, we will mention this explicitly. In all other cases, we talk about enterprise architecture as a function.

A more mature enterprise architecture possesses better performance and effectiveness in terms of IT capabilities (Meyer, Helfert, & O'Brien, 2011). Bradley, Pratt, Byrd, Outlay, & Wynn (2012) showed in their research that enterprise architecture maturity directly influences the effectiveness of hospitals IT resources for achieving strategic goals. To guide organisations in increasing their enterprise architecture maturity, several models and frameworks have been proposed throughout the years (Meyer et al., 2011). These models can help organisations improve their enterprise architecture maturity and are therefore an important tool in maturing the enterprise architecture (Bradley et al., 2012; Venkatesh, Bala, Venkatraman, & Bates, 2007).

There are several reasons why enterprise architecture in healthcare organisations is different from other organisations, most of these are concentrated around the complexity in healthcare organisations. Carvalho, Rocha, & Abreu (2016) analysed maturity models specifically for healthcare information systems and technologies. They concluded that there is a need for a maturity model which covers all areas and subsystems of a healthcare organisation. An enterprise architecture maturity model specifically tailored to hospitals could fill the gap that Carvalho et al. (2016) detected.

Another big challenge in implementing enterprise architecture in hospitals is the interoperability between hospitals, because of a lack of coordination of different information systems (Hjort-Madsen, 2006). Bygstad, Hanseth, & Truong Le (2015) summarised research on this subject and concluded that there is still too much system diversity and fragmentation in hospitals. The Dutch society of hospitals launched a program to increase the interoperability and uniformity between hospitals. From this program, the most important artefact to increase interoperability between hospitals is a reference architecture. An enterprise

reference architecture is perceived as a relevant instrument which is important to improve the quality of the enterprise architecture (ten Harmsen van der Beek, Trienekens, & Grefen, 2012). The reference architecture from the Dutch society of hospitals, hereafter called the ZiRA (in Dutch: Ziekenhuis Referentie Architectuur), is a collection of principles and models to help to structure the complex enterprise architecture in hospitals. So far, the ZiRA offers a meta-model, principles, and example models. What is missing though, is a technique to estimate to what level hospitals are utilising the ZiRA, and on which aspects they can improve. This is something that can be established with the help of a maturity model.

Summarising the previous paragraphs: there is a gap in research for an enterprise architecture maturity model specifically for hospitals, and there is an opportunity in the practice to use a reference architecture for assessing the enterprise architecture maturity of hospitals. The contribution of this research is two-fold. The first contribution is the development of a process for using reference architectures to build domain-specific maturity models. The second contribution is an enterprise architecture maturity model specifically tailored towards hospitals.

1.1.1 Research questions

Following from the gap in the research literature, we observe that there is a need for an enterprise architecture maturity models for hospitals. Therefore, we explore the possibility to design one. The main research question is:

> ***"How can we design an enterprise architecture maturity model that can be used in the context of hospitals to support the improvement process of the enterprise architecture maturity?"***

To answer the main research question, we define the following sub-questions:

RQ1: What is the state-of-the-art of the literature about enterprise architecture in hospitals, and enterprise architecture maturity models?
This question will provide insights for making an enterprise architecture maturity model specific for hospitals. The answer will show what makes hospitals special in the context of enterprise architecture and which enterprise architecture maturity models already exist.

RQ2: What are the requirements for the enterprise architecture maturity model?
The most important requirements for the design of the enterprise architecture maturity model must be accumulated. This helps us to design a model which is the best fit for hospitals.

RQ3: How can a reference architecture enrich the enterprise architecture maturity model for hospitals?
The ZiRA can be of great benefit for the enterprise architecture, especially the improvement on interoperability and uniformity of Dutch hospitals. It would, therefore, be valuable for this research to institute the knowledge from the ZiRA. With the knowledge from the ZiRA, the enterprise architecture maturity model can be improved. It is therefore important to find a solution to implement the ZiRA in the enterprise architecture maturity model.

RQ4: How does the enterprise architecture maturity model perform in one or more hospital(s)?
Eventually, the enterprise architecture maturity model is validated to ensure that it is fulfilling the goal of evaluating and improving the enterprise architecture maturity of hospitals.

How we answer these questions is explained in the next subchapter.

1.2 Research approach

To answer the research questions outlined in the previous subchapter, we conduct a design science project as described by Wieringa (2014). Within design science, there is the design cycle. The design cycle provides a logical structure of tasks to design an artefact. These tasks in the design cycle are the following: 1) Problem investigation, 2) Treatment design, and 3) Treatment validation. Figure 1 shows the design cycle for designing an enterprise architecture maturity model for hospitals. Table 1 shows how the research questions and the research approach are intertwined. The research approach itself is summarised in Figure 2.

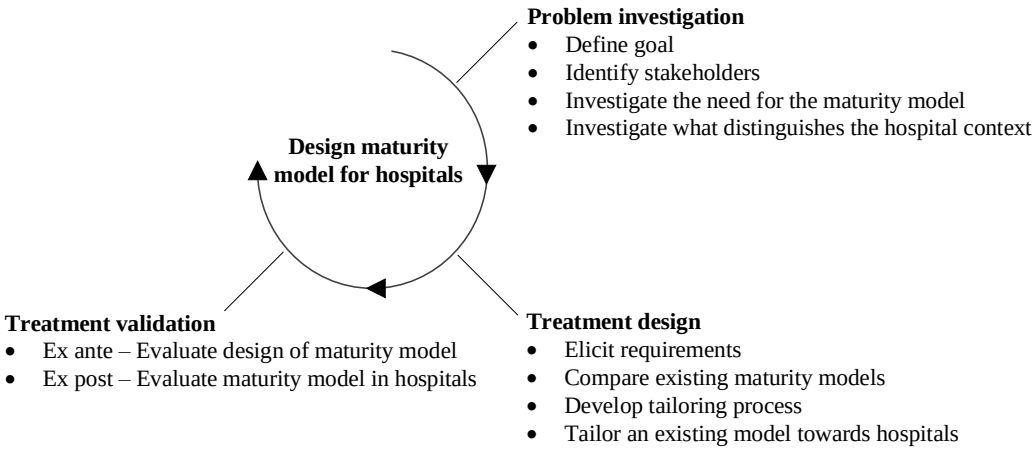

Figure 1: Design cycle, adapted from Wieringa (2014)

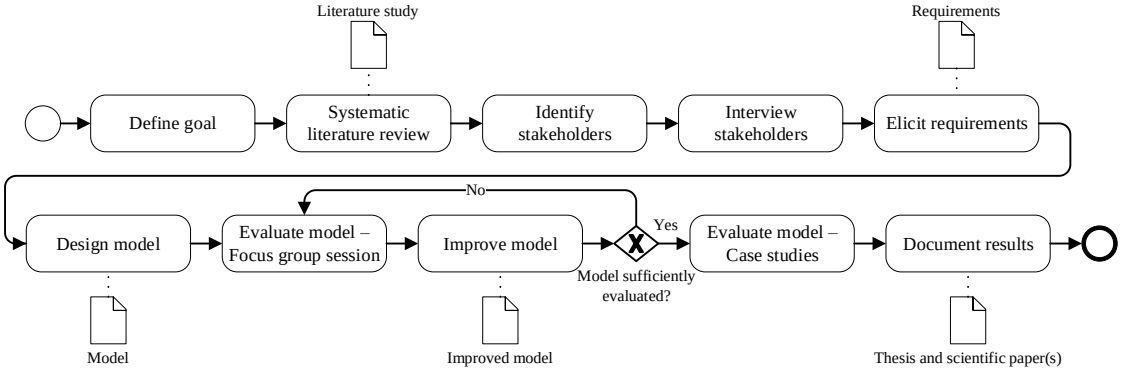

Figure 2: Summary of research approach

1.2.1 Problem investigation

In this phase of the design cycle, we define the goal of the artefact. The goal derives from investigating the need for the maturity model, from industry and from science. To establish the need from the industry, we identify and interview stakeholders. We establish the scientific need through a literature review. It is also important to understand what is special in the context of hospitals, this we investigate through literature review and interviewing stakeholders. The stakeholders should be experts involved with IT in hospitals. The literature review is presented the chapter 2.

1.2.2 Treatment design

From the same stakeholders identified during the problem investigation, we elicit requirements through interviews. Other requirements derive from literature review. These requirements are input for the design of the artefact, the creation of the enterprise architecture maturity model. Before we design the model, existing enterprise architecture maturity models are found through a systematic literature review. We use an existing model to serve as a basis and tailor it for hospitals. The tailoring we complete iteratively with the help of incorporating the ZiRA and validation through one or more focus group session(s).

Multiple iterations ensure a rigid design of the enterprise architecture maturity model for hospitals. More information on the design of the artefact is presented in chapter 3.

Table 1: The relation between the sub-questions and the research approach

Sub-Question	Research method	Phase of design cycle
RQ1	Literature review	Problem investigation & treatment design
RQ2	Interviews & literature review	Treatment design
RQ3	Interviews	Treatment design
RQ4	Focus group & case study	Treatment validation

1.2.3 Treatment validation

Some of the highly cited research about design science emphasise that evaluation is a crucial component of a design science contribution (Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). Carvalho et al. (2016) call for a maturity model in hospitals that is supported by rigorous scientific methods of validation. Therefore, it is important that we define a design science evaluation strategy. Within design science evaluation, Pries-Heje, Baskerville, & Venable (2008) define different strategies. They make a distinction on whether the evaluation is ex ante or ex post. In the ex ante perspective, the artefact is evaluated before the implementation. While in the ex post perspective, the artefact is evaluated after implementation. Next to this distinction, they make a distinction on whether the evaluation is artificial or naturalistic. Artificial evaluation takes place in a non-realistic way, like a laboratory experiment. Naturalistic evaluation explores the artefact in a real environment, like a case study. This results in a design science research evaluation framework, depicted in Figure 3.

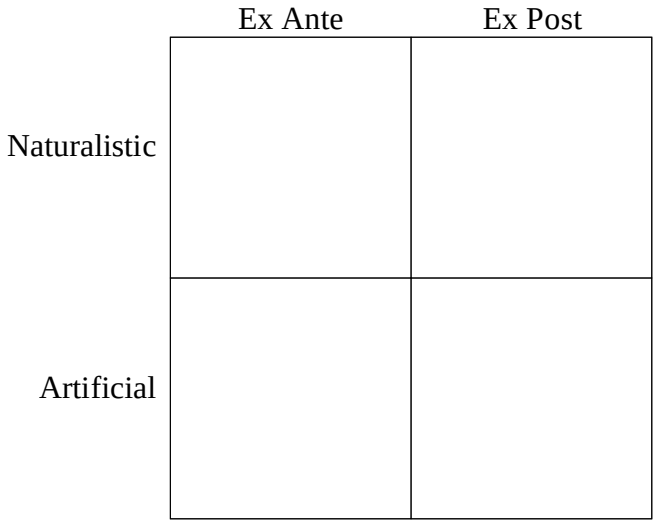

Figure 3: A strategic design science research evaluation framework (adapted from Pries-Heje et al. (2008))

To make a choice on which evaluation strategy to execute, Venable, Pries-Heje, & Baskerville (2012) made a second framework. This framework guides researchers to an evaluation strategy with input including but not limited to the level of desired rigour and type of artefact. Following their framework, this research calls for a naturalistic evaluation since the artefact produced is socio-technical, not merely technical. And to ensure a rigorous enterprise architecture maturity model, the evaluation takes place ex ante and ex post. Following the framework, methods are suggested for each quadrant in Figure 3. Figure 4 shows which methods these are, and underlined are the ones we adopt. From the methods in the top quadrants, we use a focus group for the naturalistic ex ante evaluation and a case study for the naturalistic ex post evaluation.

	Ex Ante	Ex Post
Naturalistic	• Action research • Focus group	• Action research • Focus group • Case study • Participant observation • Ethnography • Phenomenology • Survey
Artificial	• Mathematical or logical proof • Criteria-based evaluation • Lab experiment • Computer simulation	• Mathematical or logical proof • Lab experiment • Computer simulation • Role playing simulation • Field experiment

Figure 4: The different methods for design science research evaluation (adapted from Venable et al. (2012))

Traditionally, the design cycle is run through a waterfall-like process. However, we take a more agile approach. The sub-activities from the first two phases are executed in an agile way. By investigating the need for the model and what is special about the hospital context, requirements already derive. Also, the creation of the model uses an iterative investigation. While creating the maturity model, the design is ex ante evaluated. With this evaluation, we alter the design, causing another iteration between phases of the design cycle. Figure 5 displays how these iterations take place between the phases of the design cycle.

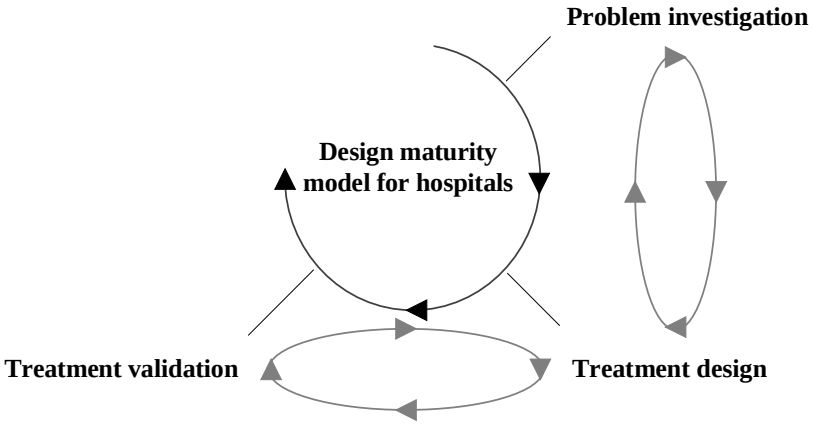

Figure 5: Iterations between the phases of the design cycle

1.3 Thesis outline

The remainder of the thesis is structured alike the design cycle. The next chapter, the background and systematic literature review, are part of the problem investigation. In the third chapter, we display the journey towards the model, alias the treatment design. The chapters 4, 5, and 6 concern the treatment validation, they respectively encompass the focus group sessions, an extra validation through an expert interview and thinking aloud sessions, and the case studies. Chapter 7 describes a discussion on the research, whereas chapter 8 presents the conclusions. Finally, the thesis is completed with the references and the appendices.

2. Background

This chapter describes the state-of-the-art literature related to this research. Firstly, we embrace the background of the field of enterprise architecture. Secondly, we focus on enterprise architecture maturity. Thirdly, we elaborate the application of enterprise architecture and its maturity in healthcare and hospitals. Fourthly, we present more background on maturity models. Fifthly, we present a systematic literature review on models for enterprise architecture maturity. Finally, the conclusions are drawn in the last subchapter.

The first three subchapters derive from a literature review. For these subchapters, we found the literature by searching in Google Scholar with the keywords shown in Table 2.

Table 2: Keywords used for systematic literature review for first subchapters

Keywords	Subchapter
"Enterprise architecture"	2.1 Enterprise Architecture
"Enterprise architecture benefits"	2.1 Enterprise Architecture
"Enterprise architecture maturity"	2.2 Enterprise Architecture maturity
"Enterprise architecture healthcare"	2.3 Enterprise Architecture in healthcare and hospitals
"Enterprise architecture hospital"	2.3 Enterprise Architecture in healthcare and hospitals

2.1 Enterprise architecture

Architecture can be described as the art and science of designing structures. These structures originate from building and construction, where a common frame of reference is important. The term architecture is not without ambiguity, is it just about the design or does it also encompass the underlying principles of a building? The same goes for enterprise architecture, an enterprise also needs a common frame of reference. To reduce ambiguity, this research incorporates the definition of enterprise architecture from Lankhorst (2017, p. 3): "a coherent whole of principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business processes, information systems, and infrastructure".

The aim of enterprise architecture, with its common frame of reference, is to build the organisation's operation. Especially the IT systems and business processes that support an organisation's core capabilities (Ross, Weill, & Robertson, 2006). This is enabled by translating the broader principles, capabilities, and goals derived from strategies into systems and processes that enable the organisation to realise their strategies.

This form of architecture in IT became widely known with the publication of the framework from Zachman (1987). This was one of the first common frame of references that organisations could use to steer their IT architecture in the right direction. The application of enterprise architecture in practice followed shortly after, Richardson, Jackson, & Dickson (1990) published in MIS Quarterly about a joint venture where enterprise architecture was of high importance. They needed enterprise architecture because the existing information technology at that time was highly incompatible to integrate into the joint venture. Because of the rapid development in IT technology at that time, Zachman (1997) predicted that enterprise architecture would be "the issue of the century".

Richardson et al. (1990) were the first to report problems in getting the enterprise architecture right. They were not the only one that were struggling, van der Raadt, Slot, & Vliet (2007) show through a case study that organisations are struggling to be truly effective with architecture. Especially the attitude towards enterprise architecture appears to be a critical success factor in being effective with enterprise architecture. Another challenge in enterprise architecture is the dispersion of different artefacts. Van Eck, Blanken, & Wieringa (2004) suggest that certain inconsistencies in rules and guidelines follow from the division of work. Since different architects work on various management levels, and their documents cover different aspects of the enterprise, there is a risk of fragmentation of the enterprise architecture.

However, despite these challenges, the majority of the literature on enterprise architecture claim that enterprise architecture benefits the business. Tamm, Seddon, Shanks, Reynolds, & Shanks (2011) have mapped enterprise architecture literature to so-called benefit enablers. The result of this mapping is the

EA benefits model, where they show that Enterprise Architecture Quality enables the following benefits: 1) organisational alignment, 2) information availability, 3) resource portfolio optimisation, and 4) resource complementarity. These, in turn, provide organisational benefits, as shown in Figure 6. Table 3 summarises the concepts collected by Tamm et al. (2011) for their benefit enablers.

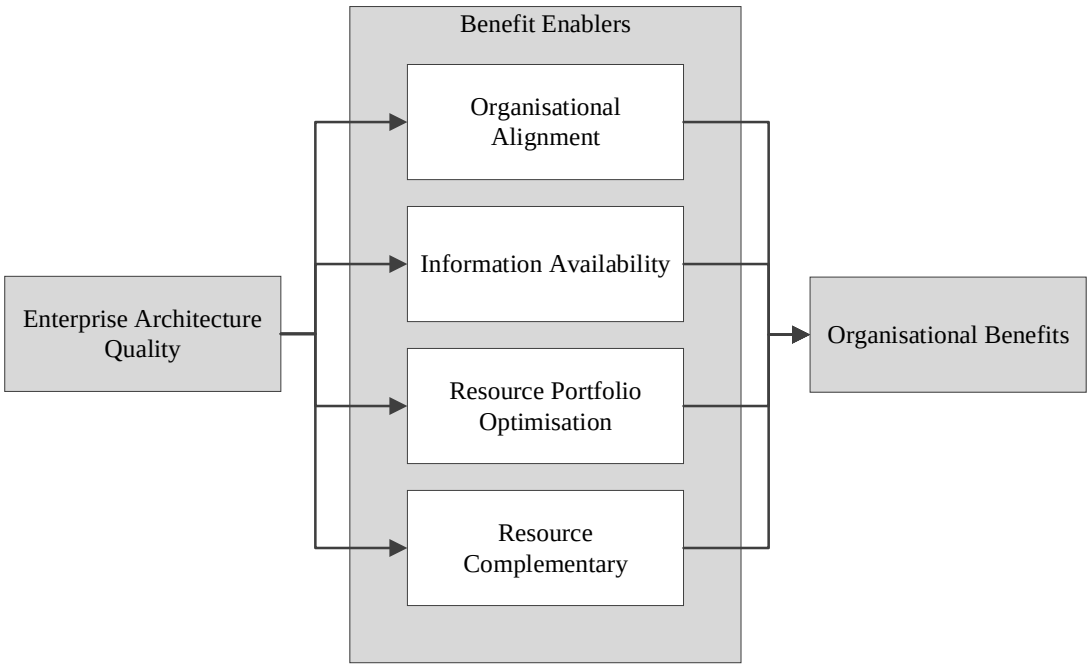

Figure 6: Enterprise Architecture Benefits Model (Tamm et al., 2011)

Table 3: Mapping of benefits to related concepts from Tamm et al. (2011)

Benefit enabler	Related concepts
Organisational Alignment	An integrated view of the enterprise, common understanding, and improved communication can lead to reduced rework (Bernard, 2005)
	A bridge between the business and technical domains, common goals and performance measures encourage cooperation rather than conflict (Pereira & Sousa, 2004)
	Better business-IT alignment and more customer intimacy (Ross et al., 2006)
	The link between organisational and information systems strategies is made stronger (Segars & Grover, 1996)
Information Availability	Standardised and shared reference information, better access to information, and improved understanding of resources/processes can benefit to better and faster decisions (Bernard, 2005)
	Better access to customer data, shared data, more manageable IT environment, improved risk management, and higher system reliability can improve customer intimacy (Ross et al., 2006)
	Common data, and more accurate, accessible and timely data can lead to improved decision-making (Spewak & Hill, 1993)
	Single sources of data improve information quality (Venkatesh et al., 2007)
Resource Portfolio Optimisation	Discovery and elimination of redundancy (Pereira & Sousa, 2004)
	Standardisation, and reduction of technologies can result in a higher return on investment from IT and better operational excellence (Ross et al., 2006)
	Fewer costly and complex interfaces, and common code (Spewak & Hill, 1993)
	Standardising IT applications and business processes can establish economies of scale (Venkatesh et al., 2007)
Resource Complementarity	Improved resource integration can improve performance (Bernard, 2005)
	Componentisation, and enhanced interoperability can increase IT responsiveness, providing strategic agility (Ross et al., 2006)

2.2 Enterprise architecture maturity

As briefly mentioned in the introduction, there is a difference in what is considered enterprise architecture. Enterprise architecture as a function describes everything mentioned in the definition from Lankhorst (2017), how does an organisation manage that? Enterprise architecture can also be seen as the actual architecture of an enterprise. If so, we speak of an enterprise architecture product instead of the function. When we mention enterprise architecture maturity, we again consider the maturity of the function of enterprise architecture, the coherent whole. If we intend the maturity of the enterprise architecture product, we will explicitly say so. Otherwise, we intend the maturity of the enterprise architecture function.

When the concept of enterprise architecture was introduced and landed in literature as well as in practice, it became clear that there was a continuing problem. Kaisler, Armour, & Valivullah (2005) introduced the need for assessing the enterprise architecture, what are the characteristics of good enterprise architecture? How does the organisation's enterprise architecture match those characteristics? This can be seen as a part of quality management and is labelled as maturity in the IT domain (Meyer et al., 2011).

When the enterprise architecture is more mature, it possesses better performance and effectiveness in terms of IT capabilities relevant for the scope of the enterprise architecture (Meyer et al., 2011). There is no widely accepted definition for enterprise architecture maturity. Therefore, we use this working definition of enterprise architecture maturity: "Enterprise architecture maturity is providing a measure of the enterprise's current stage of the performance and effectiveness of its coherent whole of principles, methods, and models to realise the principles and goals defined in the strategy of an enterprise".

The purpose herein is to mature the enterprise architecture, to increase that performance and effectiveness of the coherent whole. The objectives in maturing enterprise architecture are summarised by Meyer et al. (2011) as follows: 1) increase in performance, effectiveness, efficiency, and value generation in terms of planning, development, and operation according to the strategy, 2) decrease the expenditure of costs and time in terms of development and operation, and 3) obtain better understanding and knowledge of the enterprise and its structure as well as their evolvement. These objectives can be translated into three perspectives in enterprise architecture maturity, presented in Table 4.

Table 4: Perspectives in enterprise architecture maturity by Meyer et al. (2011)

Perspective	**Focus area**
Strategy	Sets the direction of the business and IT in a top-down approach
Architecture	Comprises the Business-, Application-, and Technology architecture
Operations	The daily work with the IT systems

To assess the status quo of the enterprise architecture maturity and provide necessary steps to take to improve that maturity, maturity models are created. More information on enterprise architecture maturity models is presented in subchapter 2.4.

2.3 Enterprise architecture in healthcare and hospitals

Wilson & Lankton (2004) provide research opportunities in information systems and healthcare. The foremost reason they provide them is that healthcare is a large and growing industry that is experiencing a major transformation in its information technology base. Bates (2002) shows that there lies a major opportunity for improving quality in healthcare by increasing the use of information technology. Some even say that there is a necessary degree of mastery of data to ensure reliable, efficient, and individualised care, only achievable with the increased use of information technology (Bates & Gawande, 2003). However, the information technology in healthcare is unique and complex, due to their highly specialised systems like medical imaging, and the broad needs of the industry, ranging from these highly specialised systems to administration systems for hospital admissions and insurance billing (Gebre-Mariam & Bygstad, 2016). Wilson & Lankton (2004) show that due to this complexity, IT change has been more rapid outside healthcare than within healthcare. A decade later, it is still reported that healthcare organisations lag behind in utilising information technology (Gandhi et al., 2016; Romanow et al., 2012). A recent study by Carvalho, Rocha, & Abreu (2016) states that health institutions are realising that they

are unable to properly manage the process of health, which is directly related to technological infrastructure limitations and management inefficiency.

Fortunately, enterprise architecture has the potential to facilitate integrating healthcare units with business architecture, making healthcare organisations exemplary types of organisations that can realise benefits from enterprise architecture (Ajer, 2018). This could have a significant impact on healthcare organisations such as hospital goal achievement (Ahsan, Shah, & Kingston, 2010). A study by Hjort-Madsen (2006) shows through a case study that interoperability challenges arise because of the lack of overall coordination of different information systems, which are decentralised in the health sector. They state that this lack of overall coordination can be improved with enterprise architecture. Bradley, Pratt, Byrd, Outlay, & Wynn (2012) take it one step further and provide evidence that enterprise architecture maturity directly influences the effectiveness of hospitals' IT resources for achieving strategic goals. They are not the only ones showing that enterprise architecture maturity has a positive influence on IT challenges in healthcare. An in-depth investigation of a US health administration system by Venkatesh et al. (2007) provides this evidence as well. The health administration system for veterans was almost abandoned since it had deteriorated that much. However, with the help of increasing the enterprise architecture maturity, they were able to dramatically transform the system and now the system is considered one of the best in the US.

Previous research has established that enterprise architecture, and its maturity, can help healthcare organisations overcome their IT challenges and achieve strategic goals. Another important aspect of enterprise architecture in healthcare organisations is the fact that they are different from organisations in other industries. Several studies have provided arguments on why the healthcare domain, in particular their IT organisation and challenges, is different than others. These studies with their arguments are summarised in Table 5.

Table 5: Arguments why enterprise architecture in healthcare organisations is different

Arguments	**Source**
Healthcare domain in enterprise architecture is significantly important due to patient's involvement, and considerably higher human/staff attachment in each healthcare task at various levels.	(Ahsan et al., 2010)
Improvement in the healthcare domain is more complex due to the complexity of its operation.	(Ahsan et al., 2010)
Laws and regulations can place significant burdens on healthcare organisations' IT units. Primarily in the areas of data and systems standardisation and integration, together with security. These laws and regulations sometimes necessitate rapid changes in their enterprise architecture.	(Bradley et al., 2012; Mc Caffery et al., 2012; Wilson & Lankton, 2004)
Competition and organisational mergers prompt healthcare IT units to execute large-scale IT integration projects.	(Bradley et al., 2012; Wilson & Lankton, 2004)
Reductions in insurance coverage lead to more competition. In the sense that patients gain increased leverage to healthcare providers to support IT technology that meets patient needs.	(Wilson & Lankton, 2004)
Medical devices and software have a safety-critical nature, making the IT organisation around these devices and software highly important.	(Mc Caffery et al., 2012)
Applications in a healthcare organisation are usually unstandardised and lack integration or interoperability. Together with the fact that healthcare organisations have more different applications than a standard organisation, they have a higher need for enterprise architecture.	(Raghupathi & Tan, 2002; Venkatesh et al., 2007)
The healthcare domain is more complex, this stems from a variety of interdependencies, with many specialisations with their own processes, technology, and data requirements.	(Bygstad et al., 2015; Gebre-Mariam & Bygstad, 2016)

The continuous arrival of new clinical methods with their own IT solution calls for a fitting enterprise architecture.	(Bygstad et al., 2015)

2.4 Enterprise architecture maturity models

As briefly mentioned in subchapter 2.2, enterprise architecture maturity models are created to assess the status quo of the enterprise architecture maturity and provide necessary steps to take to improve that maturity. In this subchapter we elaborate on the background information on maturity models. Whereas the next subchapter is a systematic literature review on enterprise architecture maturity models.

The founder of the maturity approach in the information systems field is considered to be Richard Nolan (Carvalho et al., 2016; van de Wetering & Batenburg, 2009). He was the first to propose a maturity model (Nolan, 1973). Based on a study of expenditures in information systems within organisations, he proposed a four-stage model. Later, he added two more stages to the initial model (Nolan, 1979). In this second version, the stages are initiation, contagion, control, integration, data administration, and maturity. Galliers & Sutherland (1991) revised the 'stages of growth' model from Nolan, providing a better view of how an organisation plans, develops, uses, and organises an information system and provides suggestions for progression toward higher maturity stages (Carvalho et al., 2016).

In 2002, the Software Engineering Institute at Carnegie Mellon published the Capability Maturity Model (CMM) (Chrissis, Konrad, & Shrum, 2003). Later it evolved in the Capability Maturity Model Integration (CMMI). CMMI has been established to help organisations enhance and boost their software processes and is recognised as a standard maturity model (van de Wetering & Batenburg, 2009). With its five stages of maturity, it provides a foundation on which a majority of the maturity models are based (Meyer et al., 2011). Ross (2003) was the first to introduce an architecture maturity model, her four-stage model became the first enterprise architecture maturity model and is an inspiration for many other enterprise architecture maturity models.

Within CMMI-like stage models, a distinction of two different variants can be made. Van Steenbergen, van den Berg, & Brinkkemper (2007) make a distinction on whether the model is staged or continuous. A staged model has around five maturity levels with focus areas assigned to each level. Whereas within a continuous model, there are around five levels of maturity within the different focus areas. Besides the two implementations of the CMMI, they also found a third type of model, originating from test process improvement. Koomen & Pol (1999) introduced focus area oriented models. These models usually have more maturity levels and each focus area has its own number of specific maturity levels. Figure 7 is inspired from van Steenbergen et al. (2007) and illustrates the difference between these types of models.

There is another distinction possible within the maturity models. Meyer et al. (2011) describe the difference between process-based maturity models and characteristics-based maturity models. Process-based models assign maturity levels to processes within an enterprise, measuring a set of activities performed by stakeholders. Characteristics-based models assess different characteristics, criteria, categories, or attributes (Meyer et al., 2011). Based on distinguished literature, van Steenbergen, Bos, Brinkkemper, van de Weerd, & Bekkers (2013) claim there is even another dimension. Next to the process and characteristics, which they call objects, they claim that people are also involved in the level of performance of a function.

Staged model

	1	2	3	4	5
Focus area 1	✓				
Focus area 2	✓				
Focus area 3			✓		
Focus area 4			✓		
Focus area Y					

Continuous model

	1	2	3	4	5
Focus area 1	✓	✓	✓	✓	✓
Focus area 2	✓	✓	✓	✓	✓
Focus area 3	✓	✓	✓	✓	✓
Focus area 4	✓	✓	✓	✓	✓
Focus area Y					

Focus area oriented model

	1	2	3	4	5	6	7	X
Focus area 1				✓			✓	
Focus area 2	✓		✓			✓		
Focus area 3		✓		✓				
Focus area 4	✓				✓			
Focus area Y								

Figure 7: Three different types of maturity models (adapted from van Steenbergen et al. (2007))

2.5 Systematic literature review

A systematic review helps to establish a summary of existing evidence concerning a practice or technology. Also, with the review, we can make an identification in current research, in order to help determine where further investigation might be needed (Budgen & Brereton, 2006). It is demonstrated by Tranfield, Denyer, & Smart (2003) that a systematic review lies at the heart of research which aims to serve both academic and practitioner communities.

This is not the first time that maturity models are analysed, it has been done several times in literature. Khoshgoftar & Osman (2009) studied nine different maturity models to find out which is best suited for project management. A literature study on maturity in picture archiving and communication systems by van de Wetering & Batenburg (2009) identified 34 relevant papers as input for their maturity model. Focussing on IT governance, Herz, Hamel, Uebernickel, & Brenner (2011) derived five maturity models to analyse for their solution. Meyer et al. (2011) show a relevant analysis of enterprise architecture maturity frameworks. Another review, one by Lakhrouit & Baïna (2013) also compares different enterprise architecture maturity models. However, unfortunately, both studies on enterprise architecture maturity models, do not have a selection of frameworks that is based on a systematic method or are reproductive in any manner. Nikpay et al. (2016) completed a thorough systematic literature review on post-implementation evaluation models of enterprise architecture artefacts. While they performed an extensive review, their scope was not maturity models. Another recent literature review by Carvalho et al. (2016) systematically found and compared 14 maturity models for the management of information systems and technologies. The most recent literature review on this subject was performed by Vallerand, Lapalme, & Moïse (2017). They performed a systematic analysis of enterprise architecture maturity models, however not exhaustively. This due to the fact that they had their focus on refining the notion of enterprise architecture maturity models with the integration of another discipline. By narrowing their scope, they only reported on enterprise architecture maturity models that were published by well-known private or public organisations.

Since the purpose of this systematic literature review is to find maturity models that can serve as input for the design of an enterprise architecture maturity model for hospitals, none of the previously mentioned studies can serve as input. This due to the fact that some of the studies were not performed systematically, making the review non-exhaustive. Other studies, that were performed systematically, had a different scope than enterprise architecture maturity models in their review, making these studies non-exhaustive on that subject as well. Therefore, we performed a new review.

To conduct an extensive literature review, it is necessary to define a strategy. Webster & Watson (2002) have defined a widely accepted and highly cited strategy for performing a literature review in the information systems industry. This strategy consists of three basic steps: 1) identify relevant literature in main sources, 2) review the citations for the articles in step 1, and 3) identify articles citing the key

articles from the previous steps. Steps 2 and 3 are so-called backward and forward snowballing techniques (Wohlin, 2014). Wohlin provides more detailed guidelines for these snowballing techniques. The first step in the strategy of Webster & Watson (2002) can be complemented with more detail from the method by Tranfield et al. (2003). This is shown in a recent literature review on maturity models for healthcare information systems (Carvalho et al., 2016). Eventually, the strategy from Webster & Watson (2002) serves as a basis for our approach, and with modifications and additions from Wohlin (2014) and Tranfield et al. (2003), the method for our systematic literature review is established, shown in Figure 8. The systematic literature review is performed in November 2018.

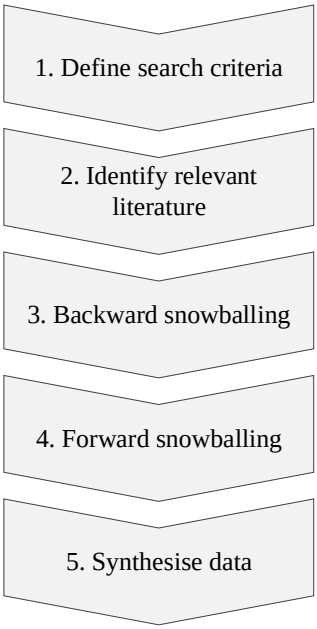

Figure 8: Systematic literature review method

2.5.1 Define search criteria

The keywords and search queries that we used as search criteria are presented in Table 6. The search criteria are used on the following major web platforms of scientific literature, as adapted from Carvalho et al. (2016): 1) AIS Electronic Library, 2) IEEE Xplore Digital Library, 3) Springer Link, 4) SCOPUS, and 5) ISI Web of Knowledge.

Table 6: Keywords and search queries used for the literature review

Search queries
“Enterprise architecture maturity” AND “model”
“Enterprise architecture maturity” AND “framework”
“Enterprise architecture maturity” AND “stages”
“Enterprise architecture maturity” AND “growth”

By using the search queries from Table 6 in the platforms described earlier, a longlist derived. Before we submitted literature to the longlist, we applied exclusion criteria, namely: 1) no access available to the literature, 2) literature is double, i.e. already derived from another search query or platform, or 3) the literature is written in a different language than English. The result is a long list of 75 articles, the distribution per scientific platform is shown in Table 7.

Table 7: Longlist literature review, number of articles per platform

Platform	**AISEL**	**IEEE**	**Springer**	**SCOPUS**	**ISI**
Number of articles	33	6	33	3	0

2.5.2 Identify relevant literature

From these 75 articles, we identified the relevant literature. The inclusion criteria used for assessing whether an article is relevant are as follows: 1) the article introduces a new enterprise architecture maturity model, 2) the article applies an enterprise architecture maturity model, or 3) the article reviews one or more enterprise architecture maturity model(s).

By applying the inclusion criteria, we identified 22 relevant articles. Most of the articles that are excluded have a different scope in their maturity model, and only mentioned that maturity models for enterprise architecture also exist. The full list of relevant articles is shown in Table 8, the last three columns show whether the article: 1) introduces a new enterprise architecture maturity model, 2) applies an enterprise architecture maturity model, and/or 3) reviews one or more enterprise architecture maturity model(s).

Table 8: Shortlist of relevant articles from the systematic literature review

#	Title	Source	1	2	3
1	Enterprise Architecture Maturity: The Story of the Veterans Health Administration	(Venkatesh et al., 2007)		✓	
2	Enterprise Architecture Maturity: A Crucial Link in Business and IT Alignment	(Robertson, Peko, & Sundaram, 2018)	✓		
3	Extending the Theory of Effective Use: The Impact of Enterprise Architecture Maturity Stages on the Effective Use of Business Intelligence Systems	(Trieu, 2013)		✓	
4	APC Forum: Creating a Platform for Innovation at Leviton Manufacturing	(Weiss, 2010)		✓	
5	The Dynamics of Sustainable IS Alignment: The Case for IS Adaptivity	(Vessey & Ward, 2013)		✓	
6	Sustainable IT Outsourcing Success: Let Enterprise Architecture Be Your Guide	(Ross & Beath, 2006)		✓	
7	The Role of Enterprise Architecture in the Quest for IT Value	(Bradley, Pratt, Byrd, & Simmons, 2011)		✓	
8	Enterprise Architecture: A Maturity Model Based on TOGAF ADM	(Proenca & Borbinha, 2017)	✓		✓
9	State of the art of the maturity models to an evaluation of the enterprise architecture	(Lakhrouit & Baïna, 2013)			✓
10	Enterprise Architecture Practices to Achieve Business Value	(Bachoo, 2018)		✓	✓
11	An Analysis of Enterprise Architecture Maturity Frameworks	(Meyer et al., 2011)			✓
12	How Enterprise Architecture Maturity Enables Post-Merger IT Integration	(Törmer & Henningsson, 2017)		✓	
13	The Dynamic Architecture Maturity Matrix: Instrument Analysis and Refinement	(van Steenbergen, Schipper, & Brinkkemper, 2010)			✓
14	A Balanced Approach to Developing the Enterprise Architecture Practice	(van Steenbergen et al., 2007)	✓		
15	Methods of the Assessment of Enterprise Architecture Practice Maturity in an Organization	(Sobczak, 2013)	✓		✓
16	A systematic review on post-implementation evaluation models of enterprise architecture artefacts	(Nikpay et al., 2016)			✓
17	Assessing the Efficiency of the Enterprise Architecture Function	(van der Raadt & van Vliet, 2009)	✓		
18	The Extended Enterprise Coherence-Governance Assessment	(Wagter, Proper, & Witte, 2012)	✓		
19	Government Process Capability Model: An Exploratory Case Study	(Gökalp & Demirörs, 2014)			✓
20	A business repository enrichment process: A case study for manufacturing execution systems	(Arab-Mansour, Millet, & Botta-Genoulaz, 2017)		✓	
21	Analysing enterprise architecture maturity models: a learning perspective	(Vallerand et al., 2017)			✓
22	The phenomenon of Information technology and enterprise architecture of electronics city	(Ali & Elnaz, 2012)			✓

In total, there are seven articles that introduce new enterprise architecture maturity models, eight articles which apply an enterprise architecture maturity model, and ten articles that review one or more enterprise architecture model(s). It must be noted here that some articles introduce a model as well as reviewing one or more model(s).

2.5.3 Backward snowballing

Now that we identified the relevant literature, we performed the backward snowballing. We applied it to all the articles, since: when a new model is introduced, there is a possibility that it is based on another, older model. If the model is applied in the article, the model itself is logically introduced in another article. And finally, when one or more model(s) were reviewed there is, of course, another source involved where the model(s) is/are introduced. This time, the inclusion criterium was that the article must introduce an enterprise architecture maturity model. The new articles that were identified are presented in Table 9. The last column shows in how many of the 22 original articles the article was cited.

Table 9: Additional articles from backward snowballing

#	Title	Source	Times cited
23	Creating a Strategic IT Architecture Competency: Learning in Stages	(Ross, 2003)	9
24	Organizational Transformation: A Framework for Assessing and Improving Enterprise Architecture Management (Version 2.0)	(United States Government Accountability Office, 2010)	10
25	NASCIO Enterprise Architecture Maturity Model	(National Association of State Chief Information Officers, 2003)	11
26	Enterprise Architecture Capability Maturity Model, Version 1.2	(United States Department of Commerce, 2007)	6
27	Extended Enterprise Architecture Maturity Model, Version 2.0	(Schekkerman, 2006)	4
28	Improving Agency Performance Using Information and Information Technology (Enterprise Architecture Assessment Framework v3.1)	(Executive Office of the President of the US - Office of Management and Budget, 2009)	1
29	Introducing an IT Capability Maturity Framework	(Curley, 2008)	1
30	Assessing Business-IT Alignment Maturity	(Luftman, 2000)	3
31	Standard CMMI® Appraisal Method for Process Improvement (SCAMPI), Version 1.3: Method Definition Document	(Software Engineering Institute of Carnegie Mellon, 2011)	4
32	COBIT® 2019 Framework: Introduction & Methodology	(ISACA, 2018)	1
33	On the Categorization and Measurability of Enterprise Architecture Benefits with the Enterprise Architecture Value Framework	(Plessius, Slot, & Pruijt, 2012)	1

The reason that most of the articles in Table 9 are not detected with the search criteria in the major scientific web platforms is that they are white papers from (governmental) institutes. This is the case for 7 of the 11 articles. The other four did not surface because they have no mention of enterprise architecture maturity in their articles. For the sake of completeness, and since at least one of the initial 22 articles claim these are enterprise architecture maturity models, they are taken into account.

2.5.4 Forward snowballing

The next step in the systematic literature review is the forward snowballing. Webster & Watson (2002) suggest that for this step, one should use the Web of Science platform. However, as Wohlin (2014) and Carvalho et al. (2016) state, it is beneficial to use Google Scholar instead. Therefore, for this step, the forward snowballing is conducted with the use of Google Scholar. The input for the forward snowballing is all the articles detected so far which introduce a new enterprise architecture maturity model, this includes all the articles identified with the backward snowballing. This time again, the purpose is to find

new enterprise architecture maturity modes, therefore, only articles which present a new enterprise architecture maturity model are taken into consideration.

For every article, we found which article(s), if any, cite that article. Table 10 shows how many times the different models got cited according to Google Scholar. Whenever a model was cited more than 100 times, a search string within these results was initiated. The search string was: "enterprise architecture maturity", as adapted from the first search criteria in Table 6. Articles 25 and 32 are not located in Google Scholar, therefore it is not possible to identify how many times they are cited. From the 279 articles identified from forward snowballing, not one is relevant in the context of enterprise architecture maturity models that is not already identified earlier in the review. This means that the systematic literature review is exhaustive, and that the data can be synthesised.

Table 10: Results from forward snowballing

Article number	Times cited	Articles after search
2	0	
8	1	
14	30	
15	9	
17	16	
18	31	
23	557	47
24	4	
25	-	
26	3	
27	41	
28	2	
29	52	
30	1242	28
31	153	1
32	-	
33	14	

2.5.5 Synthesise data

Synthesising the data consists of comparing the different enterprise architecture maturity models objectively. The goal from this comparison is to be able to draw conclusions on which enterprise architecture model is the best fit to use as input for designing the enterprise architecture maturity model for hospitals. Meyer et al. (2011) defined which key characteristics and relevant attributes there are for analysing enterprise architecture maturity models. These are adapted for the comparison of the models in this literature review. Table 11 shows the results of the comparison of the 17 identified enterprise architecture maturity models.

Table 11: Comparison between enterprise architecture maturity models

Model	Assessment Target	Number of levels & Type of Model	Type of Method	Source
Maturity Model for Effective Enterprise Architecture	Critical Success Attributes (characteristics-based)	4, staged model	None explicitly mentioned	(Robertson et al., 2018)
Maturity Model based on TOGAF ADM	Process Areas, Capabilities (process-based)	5, staged model	None explicitly mentioned	(Proenca & Borbinha, 2017)
Dynamic Architecture Maturity Matrix	Critical Success Factors (process/characteristics-based)	12, focus area oriented-model	Scoring 137 checkpoints through interviews, studying architectural documents, and using a questionnaire.	(van Steenbergen et al., 2007)

TOPAZ	Architecture Practice Aspects (process-based)	An index in percentages, continuous model	250 control questions divided into 15 control blocks, index calculated with a tool	(Sobczak, 2013)
Normalized Architecture Organization Maturity Index	Enterprise Architecture Functions (process-based)	None	SCAMPI	(van der Raadt & van Vliet, 2009)
Extended Enterprise Coherence-Governance Assessment	General Enterprise Architecture Concepts (characteristics-based)	5, continuous model	50 gradation questions, 20 open questions, and an interview	(Wagter et al., 2012)
Ross' Four Stages	IT Resources (characteristics-based)	4, staged model	None explicitly mentioned	(Ross, 2003)
Enterprise Architecture Management Maturity Framework	Critical Success Attributes (characteristics-based)	6, staged model	None explicitly mentioned	(United States Government Accountability Office, 2010)
Enterprise Architecture Maturity Model	Categories (characteristics-based)	5, staged model	They provide a toolkit to perform an assessment	(National Association of State Chief Information Officers, 2003)
IT Architecture Capability Maturity Model	IT Architecture Characteristics (characteristics-based)	5, staged model	Scorecard, which is a questionnaire	(United States Department of Commerce, 2007)
Extended Enterprise Architecture Maturity Model	Categories (process-based)	5, staged model	None explicitly mentioned	(Schekkerman, 2006)
Enterprise Architecture Assessment Framework	Capability Areas with KPIs (characteristics-based)	5, continuous model	Within KPIs for every level, measurable artefacts are defined	(Executive Office of the President of the US - Office of Management and Budget, 2009)
IT Capability Maturity Framework	Capability Building Blocks (process/characteristics-based)	5, staged model	Questionnaire to score 36 critical processes	(Curley, 2008)
Strategic Alignment Maturity Assessment Description	Business-IT alignment criteria (characteristics-based)	5, staged model	High-level process description	(Luftman, 2000)
Capability Maturity Model Integration	Process Areas, Capabilities (process-based)	5, staged model	SCAMPI, detailed process, roles, and responsibilities are described	(Software Engineering Institute of Carnegie Mellon, 2011)
COBIT	Processes (process-based)	5, staged model	None explicitly mentioned	(ISACA, 2018)
Enterprise Architecture Value Framework	Perspectives (characteristics-based)	4, continuous	Questionnaire with a measurability maturity scale	(Plessius et al., 2012)

From the 17 models, nine models have a characteristics-based assessment on the maturity, six are process-based, and two are a combination of both. Most of the models have four to six maturity levels, only one has more than six levels. Two of the models do not use stages to define the enterprise architecture maturity. Six of the models make use of at least a questionnaire to assess the maturity, whereas six others do not mention how the model should be used. The other five range from providing a high-level process description to a detailed process, roles, and responsibilities description.

2.5.6 Comparison of models

Previous literature, mostly reviews, have claimed that certain enterprise architecture maturity models are most fit for certain purposes. This subchapter elaborates on that literature. Two of the articles described in the previous subchapter performed a review on enterprise architecture maturity models with the sole purpose to find a model that fits a certain purpose best. Meyer et al. (2011) discovered that the IT Capability Maturity Framework is capable of serving as an overarching IT maturity model. On the contrary, Lakhrouit & Baïna (2013) compared several enterprise architecture maturity models and concluded that the Dynamic Architecture Maturity Matrix (DyAMM) is most suitable for evaluating enterprise architecture.

There are also articles that show arguments that certain models have their downsides. Meyer et al. (2011) mention that some approaches adopt more than five levels of maturity, like the DyAMM. These approaches provide finer granularity in their improvement steps but also bring an increased level of complexity (Meyer et al., 2011). Van Steenbergen, Bos, et al., (2010) on the other hand, aggregate limitations on fixed-level models, mostly based on earlier research. The work of de Bruin, Freeze, Kaulkarni, & Rosemann (2005) showed that fixed-level models are not geared to show interdependence between the processes that make up the maturity levels. This leads to providing little guidance to determine which process needs to be implemented first to increase the maturity level. Van de Weerd, Bekkers, & Brinkkemper (2010) in their turn sum up previous research describing that fixed-level models: 1) are found too heavy to use by several organisations, 2) are too large to implement, or even comprehend, and 3) require large resources and long-term commitment.

Van Steenbergen, Bos, et al. (2010) close their summary of limitations on fixed-levels stating that they, therefore, use a focus area maturity model. The possibility of distinguishing more than five overall stages of maturity results in smaller steps between stages. This provides more detail in guiding the prioritising of the capability development. Also, departing from the five fixed maturity levels makes the model more flexible in defining both focus areas and interdependencies.

2.6 Conclusion

This chapter describes the notion of enterprise architecture. Specifically, its benefits, maturity and why enterprise architecture in hospitals is different than in other industries. This is mostly due to the complex nature of hospitals, organisation- and IT wise. The maturity of enterprise architecture is further defined by describing the nature and history of maturity models. A systematic literature review is performed to derive all existing enterprise architecture maturity models. Other research also performed literature reviews on this subject but showed to be inexhaustive or have a different scope. 17 models are extracted from the systematic literature review, whereas most of these have four to six fixed-level stages of maturity. Comparing the existing models is part of the method to design an enterprise architecture maturity model for hospitals. This by finding an existing enterprise architecture maturity model that can serve as a basis for developing the enterprise architecture maturity model for hospitals.

Looking at the arguments from previous research on limitations and benefits on enterprise architecture maturity models, the DyAMM is the best existing model to serve as a basis for the design of the enterprise architecture maturity model for hospitals. This for the reason that the focus area-oriented model fits the complexity of hospitals. Also, the goal of the maturity model to be designed is not only to evaluate the enterprise architecture maturity of hospitals but also to support the improvement of the maturity. Finer granularity of the DyAMM provides more detail in guiding improvement.

3. The journey towards the model

This chapter describes the design of the enterprise architecture maturity model for hospitals. Firstly, the approach for the design is presented. Secondly, the DyAMM is explained in more detail since this is the base model which we use for designing one specific for hospitals. Thirdly, we elaborate on the actual design of the enterprise architecture maturity model for hospitals. Finally, the conclusions are drawn in the last subchapter.

3.1 Design approach

There are several studies that describe how to create a maturity model. Van Steenbergen, Bos, Brinkkemper, van de Weerd, & Bekkers (2010) compared most of these methods and created a development method for focus area maturity models. Our approach makes use of the comparison of best practices that van Steenbergen et al. (2010) performed. It is important to fit the phases from these best practices of developing a maturity model in our design cycle. This for the reason that there is overlap on some of the phases from the maturity model development methods and phases of the design cycle. We discovered that the procedure from Becker, Knackstedt, & Pöppelbuß (2009) fits best in our approach. This due to the fact it suits best the iterative nature in our design cycle. Our approach for creating the enterprise architecture maturity model consists of the following adapted phases: 1) Requirements gathering, 2) Comparison of existing maturity models, 3) Iterative maturity model development.

We complete the first two phases in parallel. The requirements derive from existing literature, and from interviews with IT professionals that have experience in healthcare. Concurrently, we compare existing enterprise architecture maturity models as presented in subchapter 2.5. Wendler (2012) states that: "researchers should carefully search for existing models before developing new ones on the one hand, and take care to examine the suitability of existing models for the intended purpose on the other hand". Also, Becker et al. (2009) emphasised the importance to identify existing maturity models for identical domains that can serve as a starting point for further development. Therefore, we select an existing model that might fit the purpose of evaluating and improving enterprise architecture maturity in hospitals. By checking the requirements to this existing model, we know which alterations we need to make. We then tailor the model, starting with an existing model and making it specific for our context. An iteration takes place with validating the design through a focus group, after which we adjust the model again. This design approach is summarised in Figure 9. This chapter elaborates on the highlighted steps in the process.

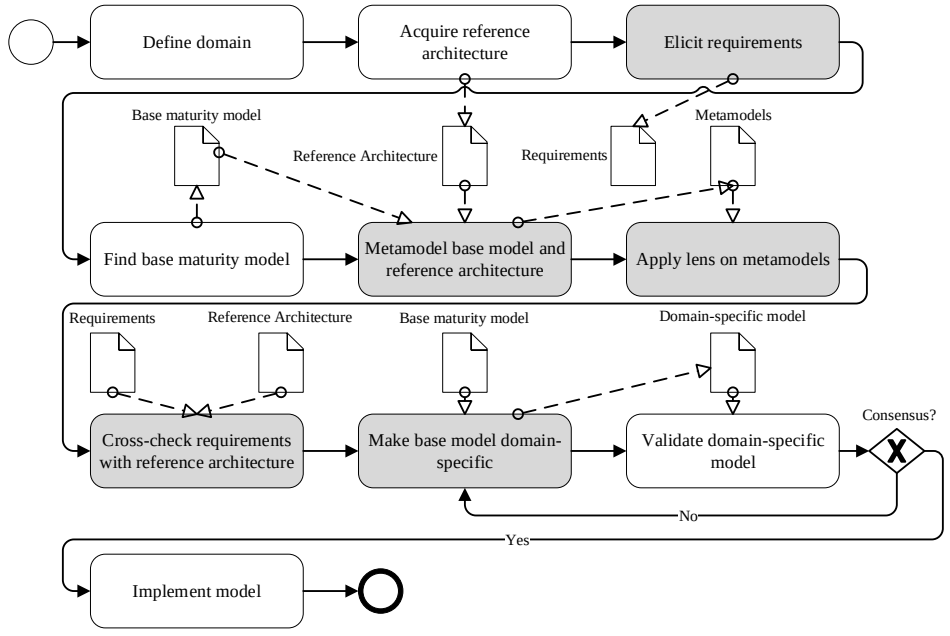

Figure 9: Process for designing the enterprise architecture maturity model for hospitals

3.1.1 Requirements

The requirements derive from existing literature identified in chapter 2, and from expert interviews. These interviews gave insight into the wishes and needs of the experts in practice. The interviews were semi-structured and the following questions were asked to the experts:

1. What would you like to achieve when using an enterprise architecture maturity model for hospitals?
2. How would you like to use an enterprise architecture maturity model for hospitals?
3. Which specific aspects of the enterprise architecture of a hospital would you like to assess with the enterprise architecture maturity model?

The interviews were recorded, transcribed, and then coded in NVivo. In total, three interviews were conducted. Table 12 shows the experience of each interviewed expert. Two of the interviews were recorded and transcribed. One interviewee was not able to be interviewed in person, he provided the answers to the questions by e-mail. The requirements are presented in Table 13, where the third column shows the source of the requirements. Some of the requirements derived from the literature review, whereas others derived from the interviews. The last column shows whether the requirement is functional or non-functional. Functional requirements involve the function of the model. For example, the aspects the model should evaluate or realise. Non-functional requirements cover the operation of the model. For example, how the model should be used. We intend to implement all the requirements in the design of the enterprise architecture maturity model for hospitals.

Table 12: Work experience of the interviewees for the requirements

Interviewee	Experience
1	28 years in (healthcare) IT
2	18 years in healthcare IT, of which 13 as an architect
3	37 years in healthcare IT, of which 15 as an architect

Table 13: Requirements for the enterprise architecture maturity model for hospitals

#	Requirement	Source	Type
1	The model should evaluate the maturity level	Interviews 2 & 3	Functional
2	The model should give suggestions for improving the maturity level	Interviews 2 & 3	Functional
3	The model should incorporate parts of the ZiRA	Interviews 2 & 3	Functional
4	The model should have more than six maturity levels	(van Steenbergen, Bos, et al., 2010)	Functional
5	The model should have multiple focus areas	(van Steenbergen, Bos, et al., 2010)	Functional
6	The model should have a holistic approach	Interview 3, (Carvalho et al., 2016; Meyer et al., 2011)	Non-functional
7	The model should evaluate whether the enterprise architecture is based on standard information concepts	Interview 1	Functional
8	It should be possible to perform a benchmark with other hospitals with the model	Interviews 2 & 3	Non-functional
9	The model should be easy to use	Interviews 2 & 3	Non-functional
10	Using the model should not take too much time, and give results fast	Interview 2	Non-functional
11	The model should evaluate the processes involved around the enterprise architecture	Interview 3	Functional
12	The model should evaluate whether the hospital is interoperable in the ecosystem	Interviews 1 & 3	Functional
13	The model should evaluate whether the as-is enterprise architecture is modelled	Interview 3	Functional
14	The model should evaluate which tools you are using	Interview 3	Functional

3.2 DyAMM as a starting point

The Dynamic Architecture Maturity Matrix (DyAMM) is shortly introduced in the systematic literature review. But since we are using it as a basis, it deserves a more thorough introduction. The DyAMM is a focus area oriented maturity model, presented in Figure 10. The information in this subchapter is gathered from multiple publications about the DyAMM (van Steenbergen et al., 2013, 2007; van Steenbergen, Schipper, et al., 2010). DyAMM breaks the enterprise architecture function within an organisation down to 17 focus areas. All these 17 focus areas should receive attention in order to have an effective enterprise architecture practice. For every focus area, there are maturity levels defined, A, B, C, and D, where A is the lowest and D the highest level. These different maturity levels are divided throughout the maturity matrix. Some of the maturity levels are more necessary to achieve in an immature enterprise architecture than others, these are positioned on an earlier scale in the matrix.

To use the DyAMM for step by step improvement, one moves from left to right in the matrix. You first make sure that you reach maturity level A of the focus areas in scale 1; Development of architecture, Alignment with business strategy, and Commitment and motivation. If these are achieved, the organisation is at maturity scale 1. The next step is to make sure that you reach maturity level A of; Use of architecture, Alignment with realisation, and Interaction and collaboration. It is possible that an organisation should reach a maturity level B of a certain focus area before even having maturity level A on another focus area. See for example focus area 'Quality assurance', with maturity level A on scale 7, and focus area 'Development of architecture' with maturity level B on scale 4.

#	**Focus Area**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	Development of architecture		A			B			C					
2	Use of architecture			A			B				C			
3	Alignment with business strategy		A			B					C			
4	Alignment with realisation			A				B			C			
5	Relationship to the As-Is state					A				B				
6	Responsibilities and authorities				A		B					C		
7	Alignment with change portfolio				A				B		C			
8	Monitoring				A		B		C					
9	Quality assurance								A		B		C	
10	Management of the architectural process							A		B		C		
11	Management of the architectural products					A			B					C
12	Commitment and motivation		A					B		C				
13	Implementation of the architectural role				A		B		C				D	
14	Architectural method				A					B			C	
15	Interaction and collaboration			A		B				C				
16	Architectural tools							A				B		C
17	Budget and planning					A						B		C

Figure 10: Dynamic Architecture Maturity Matrix 3.0

The maturity scale of an organisation is determined by looking which maturity level blocks the next scale. An organisation achieves a scale of maturity when all the levels at that scale and at all the previous scales have been attained. For example: if all the focus areas are on maturity level C, except for focus area 'Development of architecture', which is at maturity level A, the maturity scale of the organisation is at 3. It is possible to distinguish the following stages, when the maturity scale is at respectively 3, 6, 8, 10, and 12:

- Stage 3: a start is made on the employment of architecture. The most important focus areas are developed to a basic level. There is an awareness that architecture must be embedded into the organisation and work is being done on this matter
- Stage 6: nearly all the focus areas are developed to a basic level. Consideration is given to architecture as a process. Architectural practices are structurally established.
- Stage 8: architecture now facilitates the most important organisational changes. There is commitment throughout the organisation.

- Stage 10: architecture is used as an integral part of all the changes occurring in an organisation. Architectural practices are integral to the organisation.
- Stage 12: architectural practices are at such a high level of proficiency that architectural processes and products are continuously optimised.

An organisation can also assess its enterprise architecture practice by filling in the DyAMM. For every maturity level for every focus area, there are checkpoints defined. This results in a total of 136 checkpoints. The following rule is then applied to determine on which maturity scale the organisation is: An organisation attains a maturity level when all the checkpoints at that level and all preceding levels have been satisfied.

The DyAMM shows which focus area deserves the most attention. It also shows suggestions for improvement which an organisation can follow. For every maturity level at every focus area, there are suggestions for improvement available.

3.3 The design of the model

Van Steenbergen, Bos, et al. (2010) describe a development method specifically for focus area maturity models. Therefore, we chose to follow this method for developing our model. One of the benefits is that the method by van Steenbergen et al. (2007) fulfils all the requirements stated by Becker et al. (2009) for the development of maturity models, making the methods suitable to blend into each other.

The method described by van Steenbergen, Bos, et al. (2010) is as follows: 1) Identify & scope domain, 2) Determine focus areas, 3) Determine capabilities, 4) Determine dependencies, 5) Position capabilities in matrix, 6) Develop assessment instrument, 7) Define improvement actions, 8) Implement maturity model, 9) Improve matrix iteratively, and 10) Communicate results. These steps are arranged in four groups, being: 1) Scoping, 2) Design model, 3) Develop instrument, and 4) Implementation and exploitation. This subchapter focusses on the first three groups, excluding the implementation and exploitation.

To specify the DyAMM for hospitals, we look for possibilities in the DyAMM where we can make changes. We configured a metamodel in a UML class diagram. The metamodel of a focus area maturity matrix in Figure 11 is inspired from van Steenbergen et al. (2013) and shows what the components are of a focus area maturity matrix. As we can see from the method described by van Steenbergen, Bos, et al. (2010), there are a couple of steps where we can change the DyAMM. Changes to the DyAMM are made to the components in Figure 11. To get an overview of how the ZiRA can be incorporated in the DyAMM, we made a similar metamodel of the ZiRA. This metamodel is shown in Figure 12.

We apply a lens to both metamodels to see where the possibilities of enrichment from the ZiRA lie. One of the possibilities is to look at the components of both the metamodels and see whether a component incorporates the enterprise architecture process domain or the enterprise architecture product domain. This differentiation is one we encountered during the literature review, as described in subchapter 2.4. A brief summary is as follows: a model can focus on certain dimensions, where the process dimension focusses on the processes about enterprise architecture in place at an organisation and the product dimensions focusses on deliverables, categories, characteristics, or attributes of the enterprise architecture (Meyer et al., 2011; van Steenbergen et al., 2013). It is possible to define more dimensions, Mettler & Rohner (2009) for example argue that one should take people also into account when assessing maturity. However, to make the distinction not too complex, and since people are usually part of a process, we only look at whether the components encompass the process, or the product dimension. In Table 14 we show the components from the metamodels, and whether they cover the process, product, neither, or both dimension(s). When they cover both, it means that entities from the component can cover the process or product dimension.

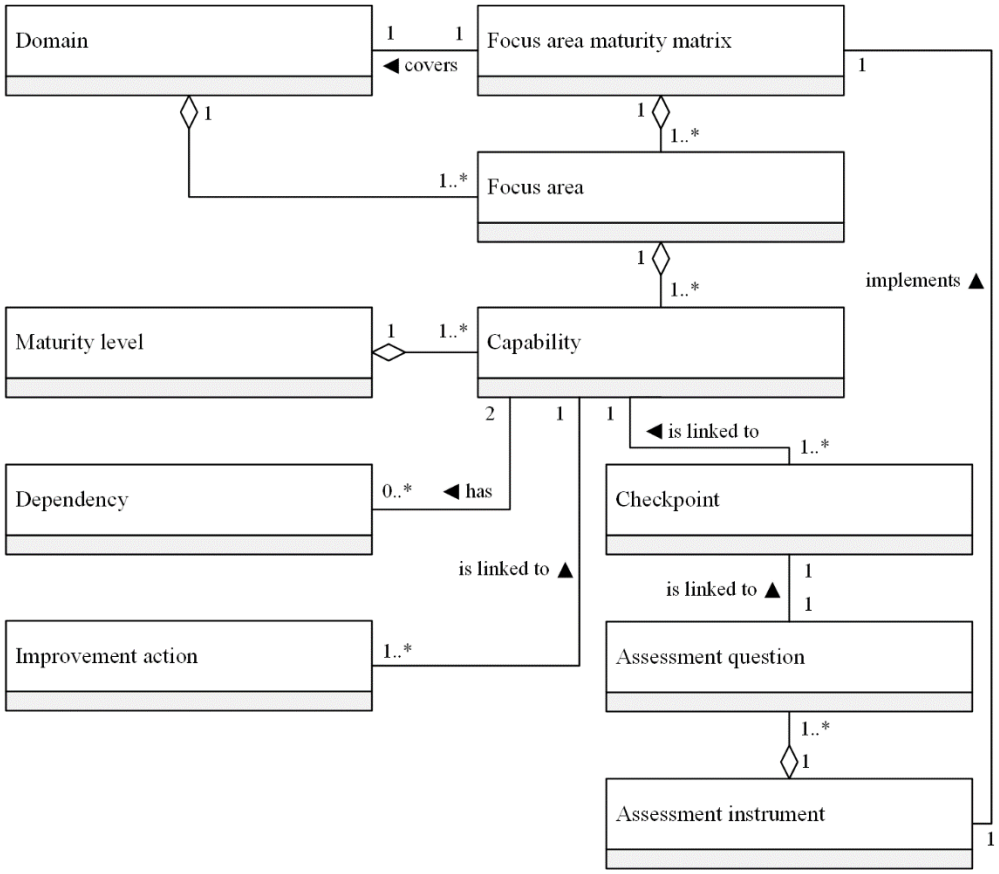

Figure 11: Metamodel focus area maturity matrix (van Steenbergen et al., 2013)

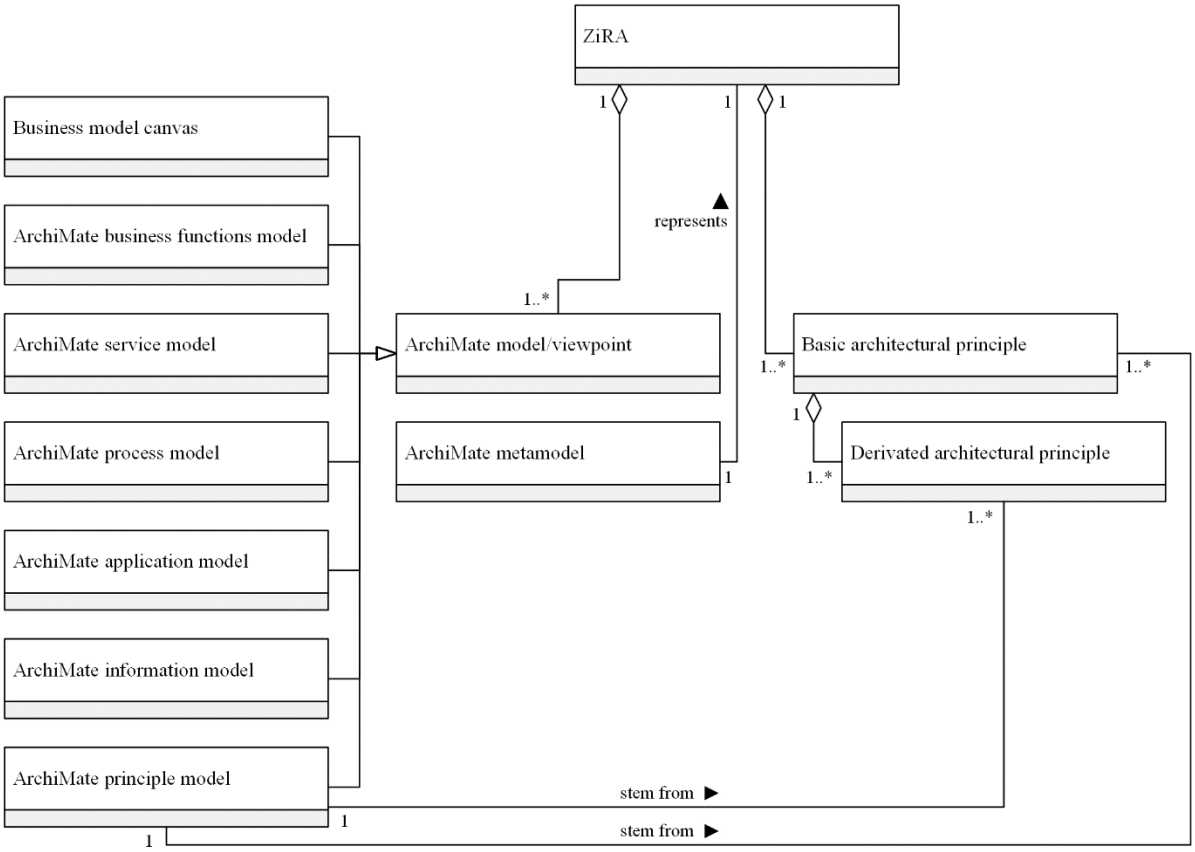

Figure 12: Metamodel ZiRA

Table 14: Components ZiRA and DyAMM and their dimension

Component	Metamodel	Dimension
Domain	DyAMM	Both
Focus area maturity matrix	DyAMM	Both
Focus area	DyAMM	Both
Maturity level	DyAMM	Both
Capability	DyAMM	Both
Dependency	DyAMM	Both
Checkpoint	DyAMM	Both
Assessment question	DyAMM	Both
Assessment instrument	DyAMM	Both
Improvement action	DyAMM	Both
ZiRA	ZiRA	Both
ArchiMate metamodel	ZiRA	Product
ArchiMate model/viewpoint	ZiRA	Product
Business model canvas	ZiRA	Product
ArchiMate business functions model	ZiRA	Product
ArchiMate service model	ZiRA	Product
ArchiMate process model	ZiRA	Product
ArchiMate application model	ZiRA	Product
ArchiMate information model	ZiRA	Product
ArchiMate principle model	ZiRA	Product
Basic architectural principle	ZiRA	Process
Derivated architectural principle	ZiRA	Both

Table 14 shows that the components of the ZiRA are clearly separated, and most of them focus on the product dimension of the enterprise architecture. Only the basic principles focus on the process dimension and the derivated principles focus on both. The components from the DyAMM are not that easily separable since the focus areas mostly cover both domains. To find out what domains are covered in a focus area, we look at the most granular level of a focus area. These are the checkpoints, which make up the capabilities, which make up the focus area. At this lowest level of granularity, we have examined whether a checkpoint encompasses the product domain, the process domain, or both. In Table 15 we present the focus areas of the DyAMM and how many checkpoints within the focus area encompass the product, the process, or both the domains. In Appendix B we show all the different checkpoints, showing which domain(s) they cover, to which capability they are linked, and in which focus area they belong.

The analysis shows that the most checkpoints focus on the process domain (68 out of 136), whereas 53 checkpoints focus on both the domains. When a checkpoint focuses on both domains, the checkpoint usually describes a process wherein an architectural product is involved, or vice versa. A minority of 14 checkpoints merely focus on the product domain.

When comparing the focus areas, and the number of checkpoints per domain, it shows that most focus areas have an emphasis on the process domain. Nine focus areas have more checkpoints in the process domain than in the product domain, or in both the domains. Seven focus areas have a majority of checkpoints which cover both domains, they do not emphasise on one or the other. Only one of the focus areas has more checkpoints in the product domain than in the process domain, or in both the domains.

It is important to keep in mind which checkpoints, capabilities, and focus areas focus on which domain when tailoring it specifically for hospitals. When parts of the ZiRA get incorporated, this will help establish a better alignment with the DyAMM.

Table 15: Number of checkpoints per domain for focus areas DyAMM

Focus area	**Number of checkpoints per domain**			
	Process	**Product**	**Both**	**Total**
1. Development of architecture	2	4	5	**11**
2. Use of architecture	5	2	2	**9**
3. Alignment with business strategy	6	0	2	**8**
4. Alignment with realisation	6	0	3	**9**
5. Relationship to the As-Is state	1	4	2	**7**
6. Responsibilities and authorities	5	0	3	**8**
7. Alignment with change portfolio	2	0	4	**6**
8. Monitoring	2	0	6	**8**
9. Quality assurance	3	0	5	**8**
10. Management of the architectural process	9	0	0	**9**
11. Management of the architectural products	0	0	9	**9**
12. Commitment and motivation	5	0	1	**6**
13. Implementation of the architectural role	9	0	1	**10**
14. Architectural method	0	2	5	**7**
15. Interaction and collaboration	9	0	0	**9**
16. Architectural tools	0	2	4	**6**
17. Budget and planning	5	0	1	**6**
Total:	**69**	**14**	**53**	**136**

The next step is to make a selection of components of the ZiRA that possibly have added value and can be integrated into the DyAMM. To make a selection from these components, we look at the requirements for an enterprise architecture maturity model for hospitals from Table 13. For every instance of a component, we checked whether they are in line with one of the requirements. This analysis shows that the components of the ZiRA in the product domain are in line with one of the requirements, namely requirement 3: 'The model should incorporate parts of the ZiRA'. This requirement is abstract though and therefore it is hard to judge which parts should be incorporated. However, the actual example models/viewpoints hold value in the sense that they can be used by hospitals to get inspired from or to use as a basis. Therefore, we look for opportunities to incorporate the knowledge from these models/viewpoints in the maturity model.

When comparing the architectural principles from the ZiRA to the requirements though, it shows that there are certain principles which are clearly in line with the less abstract requirements. The structure of the basic and derivated architectural principles are also comparable to components of the DyAMM. A basic architectural principle like 'The hospital works in close connection with the ecosystem' has the same imperative nature as a capability component from the DyAMM like 'Architecture is developed with a clear focus on objectives'. Table 16 shows which basic and derivated principles are in line with which requirement(s) from Table 13.

Table 16: Connection between ZiRA components and requirements

ZiRA component	**Description**	**Requirement**
Basic principle	The hospital works in close connection with the ecosystem	13
Basic principle	Univocal and one-time-only storage of data for multiple use	13
Basic principle	The delivered quality is made transparent through primary care process registration	7
Derivated principle	Applications are service oriented and are loosely coupled	8
Derivated principle	Process standardisation is based on generic process models	12
Derivated principle	Transmural care processes conform to national policies and guidelines	12
Derivated principle	Agreements on interoperability are made between involved care institutions	13

Derivated principle	The exchange of data is based on the specification of standard care information concepts	7 & 13
Derivated principle	Registration at the source (a Dutch program for making sure that all care data is stored univocally and one-time only)	13
Derivated principle	Disconnect the technological components as much as possible	8
Derivated principle	Processes are standardised, flexible, and consist of reusable work processes and process steps	12
Derivated principle	When making questionnaires, patients and caretakers are involved, and standard care information concepts are used	7
Derivated principle	Systems are able to store and send standard care information concepts	7
Derivated principle	Message exchange is based on standards	13

3.3.1 Determine focus areas

First, according to van Steenbergen, Bos, et al. (2010), the focus areas must be determined. Since the 17 focus areas of the DyAMM have already been proven to be valuable for assessing enterprise architecture maturity, we do not remove or change any of these original focus areas (van Steenbergen, Schipper, et al., 2010). However, it is possible to add one or more focus areas, since a number of around 20 focus areas on average is good (van Steenbergen, Bos, et al., 2010). When cross-checking whether the principles in Table 16 focus on the same focus area as one already defined in the DyAMM, it shows that most of them focus on a different area. The main theme recurring in the principles is the interoperability of a hospital. This challenge is also mentioned in the literature (Bygstad et al., 2015; Hjort-Madsen, 2006) and rose from the expert interviews. Therefore, following this triad of evidence, we chose to add the focus area 'Interoperability'.

The actual models from the ZiRA do not blend very well with the existing focus areas of the DyAMM. Although some of the focus areas address the product view of the enterprise architecture, none is that specific on actual architectural models. To incorporate the knowledge from these models to assess the maturity, we add the focus area 'Utilisation of ZiRA models'. This focus area should assess whether a hospital use the models from the ZiRA as inspiration for their own architectural models.

This makes a total of 19 focus areas for the enterprise architecture maturity model for hospitals. Table 17 shows these focus areas with a description per focus area.

Table 17: Focus areas of the enterprise architecture maturity model for hospitals

Focus area	Description
Development of architecture	The development of architecture can be undertaken in various ways, varying from isolated, autonomous projects to an interactive process of continuous facilitation in which all architectural initiatives are coordinated and the right stakeholders are being involved.
Use of architecture	The uses of architecture can merely be a conduit for information, or it may be a means of governing individual projects, or even a tool for managing the entire organisation.
Alignment with business strategy	This is about the connection between the choices made in the architecture and the business goals.
Alignment with realisation	This is about how the realisation process is synchronised with the overarching architectural process.
Relationship to the As-Is state	When designed the desired to-be state, it is important to realise that there is already an existing situation, this relationship between the two must not be ignored.
Responsibilities and authorities	Roles and responsibilities concerning architectural thinking and acting should be clearly and unambiguously outlined.
Alignment with change portfolio	Some of the developments in the hospital are interrelated, architecture can be the control instrument to make sure that the content of such development is coordinated.
Monitoring	The hospital should not only state that projects comply with the architecture but should also have a control mechanism in place.
Quality assurance	Obviously, the successful employment of architecture depends upon its quality. The goal of quality assurance is to ensure such quality.

Management of the architectural process	The architectural process needs to be maintained to safeguard the effectiveness and efficiency of architecture.
Management of the architectural products	It is not enough to deliver architectural products, they must also be maintained.
Commitment and motivation	Commitment and motivation of the architecture stakeholders is critical in bringing the architecture up to speed and making it successful.
Implementation of the architectural role	An architect needs a broad skillset. Defining the architect's role and providing the necessary training is an important concern
Architectural method	The way the hospital develops its architecture is a methodical procedure made up of activities, techniques, tools and deliverables.
Interaction and collaboration	A great deal of interaction and collaboration among various stakeholders is required in developing architecture.
Architectural tools	Working with architecture can be aided by architectural tools. They should be well suited to their task.
Budgeting and planning	The development of architecture can be budgeted and planned. Careful budgeting and planning helps de-mystify architecture.
Interoperability	The architecture should not only focus on the internal organisation but also keep in mind to become and stay interoperable in the ecosystem.
Utilisation of ZiRA models	Models from the ZiRA derived from best practices, hospitals can benefit from using these models to improve their own architectural models.

3.3.2 Determine capabilities

The capabilities are maturity levels within every focus area, these are the letters in Figure 10. They correspond to a certain maturity scale of the matrix. To which scale they belong though, is established in the next steps of the method. This step determines which capabilities make up a focus area. Since we did not remove any of the existing focus areas in from the DyAMM, we also do not remove any capabilities from the DyAMM. However, to make the capabilities more aligned towards hospitals, some may need to be changed. Also, some capabilities are added, since we added the focus areas 'Interoperability', and 'Utilisation of ZiRA models'.

To check whether an original capability from the DyAMM needs to be changed towards hospitals, we compare them with the principles and requirements. Should they touch a principle or requirement, we assess whether the capability can and should be tailored towards hospitals. But firstly, we address the capabilities of the new focus areas, 'Interoperability', and 'Utilisation of ZiRA models'.

Interoperability

It is a good practice to base the determination of a new focus area and its capabilities on proven literature if available (van Steenbergen, Bos, et al., 2010). At the most abstract level, interoperability is a means to achieve integration (Chen & Vernadat, 2003). In literature, we found that multiple classifications of the interoperability process exist, even maturity models. Panetto (2007) reviewed the existing maturity models on interoperability. The identified models have a different scope, Table 18 shows the different existing maturity models for interoperability identified by Panetto (2007).

Table 18: Different interoperability maturity models

Model	Scope	Source
Levels of Information Systems Interoperability (LISI)	Systems interoperability	(C4ISR Architectures Working Group, 1998)
Organizational Interoperability Maturity Model (OIM)	Organisational interoperability	(Clark & Jones, 1999)
NATO C3 Technical Architecture Reference Model for Interoperability	Data exchange interoperability	(NATO, 2003)
Levels of Conceptual Interoperability Model (LCIM)	Conceptual interoperability	(Tolk & Muguira, 2003)

These four maturity models exist of different maturity levels and are therefore fit to serve as input for the capabilities of the focus area 'Interoperability'. Looking at the scopes of the existing models and the requirements and principles from the ZiRA, the OIM seems to be the best fit to use. This since the interoperability of the hospitals in the ecosystem is the subject, therefore being organisational interoperability. The different levels of the OIM are level 0 – independent, level 1 – ad hoc, level 2 –

collaborative, level 3 – integrated, and level 4 – unified. These levels are easily translated to capabilities. Table 19 shows the capabilities for the focus area 'Interoperability'.

Table 19: Capabilities of the focus area 'Interoperability'

Capability	Description
A	Limited frameworks are in place which allows for ad hoc interoperability arrangements
B	Recognised frameworks are in place to support collaborative interoperability
C	Shared value systems and shared goals provide integrated interoperability
D	Interoperating on a continuing basis makes a unified interoperability

Utilisation of ZiRA models

Ten Harmsen van der Beek et al. (2012) define different research areas for enterprise reference architectures. Amongst them is one specified towards the product area, they defined an artefact in this area which they describe as: "An assessment model to assess the concrete enterprise architecture against the enterprise reference architecture" (ten Harmsen van der Beek et al., 2012, p. 104). This is what we want to achieve with this focus area and its capabilities.

Unfortunately, we could not identify more literature to base the capabilities on. To establish capabilities for this focus area, we look at focus areas of the DyAMM that are similar. Similar in the sense that they also focus more on the product domain than on the process domain of the enterprise architecture. These are the focus areas 'Development of architecture', 'Relationship to the As-Is state', 'Architectural method', and 'Architectural tools'. Table 20 shows the corresponding capabilities of these focus areas.

Table 20: Capabilities of focus areas as inspiration for 'Utilisation of ZiRA models'

Focus area	Level A	Level B	Level C
Development of architecture	Architecture is developed with a clear focus on objectives	Architecture is developed in consultation with the stakeholders	Architectures are developed as a cohesive whole
Relationship to the As-Is state	Attention to the As-Is state	Future and existing situations are viewed in connection	
Architectural method	Ad hoc	Structural	Fully incorporated
Architectural tools	Ad hoc and product-oriented	Structural and process-oriented	Integration of tools

The capabilities from these focus areas inspired the capabilities for the focus area 'Utilisation of ZiRA models'. We applied a similar structure of levels of the last two focus areas in Table 20. The result is presented in Table 21.

Table 21: Capabilities of the focus area 'Utilisation of ZiRA models'

Capability	Description
A	Ad hoc, when making new models there is attention paid to the ZiRA
B	Structural, all new models are inspired and connected to the ZiRA
C	Fully incorporated, all models from the ZiRA are present in the hospital's architecture

Now that we have defined the capabilities for the new focus areas, we address the capabilities of the original focus areas. Per focus area, we address whether their original capabilities need changes to tailor them towards hospitals.

Development of architecture

Within this focus area, the development of architectural products is assessed. We made some slight changes to the capabilities, choosing a different wording to make it more obvious that the architecture products are suggested in the capabilities. And we tailored them more towards hospitals. Capability A from this focus area is changed from 'Architecture is developed with a clear focus on objectives' to 'Architecture products are developed with a clear focus on the hospital's objectives'. Capability B is changed from 'Architecture is developed in consultation with the stakeholders' to 'Architecture products are developed in consultation with the relevant hospital's stakeholders'. Capability C is changed from

'Architectures are developed as a cohesive whole' to 'Architecture products are developed as a cohesive whole'. Table 22 shows the capabilities for the focus area 'Development of architecture'.

Table 22: Capabilities of the focus area 'Development of architecture'

Capability	Description
A	Architecture products are developed with a clear focus on the hospital's objectives
B	Architecture products are developed in consultation with the relevant hospital's stakeholders
C	Architecture products are developed as a cohesive whole

Use of architecture

Within this focus area, no changes are made to the capabilities. Table 23 shows the capabilities for the focus area 'Use of architecture'.

Table 23: Capabilities of the focus area 'Use of architecture'

Capability	Description
A	Architecture is informative
B	Architecture is prescriptive
C	Architecture is aligned with the decision-making process

Alignment with business strategy

Capabilities from this focus area are tailored more towards hospitals. Capability A is changed from 'Architecture is related to business objectives' to 'Architecture is related to the hospital's business objectives'. Capability B is changed from 'Architectural process is steered by the business objectives' to 'Architectural process is steered by the hospital's business objectives'. Capability C is not changed. Table 24 shows the capabilities for the focus area 'Alignment with business strategy'.

Table 24: Capabilities of the focus area 'Alignment with business strategy'

Capability	Description
A	Architecture is related to the hospital's business strategy
B	Architectural process is steered by the hospital's business objectives
C	Architecture is an integral part of the strategic dialogue

Alignment with realisation

Within this focus area, no changes are made to the capabilities. Table 25 shows the capabilities for the focus area 'Alignment with realisation'.

Table 25: Capabilities of the focus area 'Alignment with realisation'

Capability	Description
A	Ad hoc
B	Structural
C	Interactive

Relationship to the As-Is state

The capabilities within this focus area are tailored more towards hospitals. Capability A is changed from 'Attention to the As-Is state' to 'Attention to the As-Is state of the hospital'. Capability B changed from 'Future and existing situations are viewed in connection' to 'Future and existing situations of the hospital are viewed in connection'. Table 26 shows the capabilities for the focus area 'Relationship to the As-Is state'.

Table 26: Capabilities of the focus area 'Relationship to the As-Is state'

Capability	Description
A	Attention to the As-Is state of the hospital
B	Future and existing situations of the hospital are viewed in connection

Responsibilities and authorities
Some of the capabilities in this focus area are more tailored towards hospitals. Capability A is not changed. Capability B is changed from 'Management is responsible for the architectural process' to 'Hospital management is responsible for the architectural process'. Capability C is changed from 'Senior management is responsible for the effect of architecture' to 'Hospital senior management is responsible for the effect of architecture'. Table 27 shows the capabilities for the focus area 'Responsibilities and authorities'.

Table 27: Capabilities of the focus area 'Responsibilities and authorities'

Capability	Description
A	Responsibility for the architecture as a product has been assigned
B	Hospital management is responsible for the architectural process
C	Hospital senior management is responsible for the effect of architecture

Alignment with change portfolio
Within this focus area, no changes are made to the capabilities. Table 28 shows the capabilities for the focus area 'Alignment with change portfolio'.

Table 28: Capabilities of the focus area 'Alignment with change portfolio'

Capability	Description
A	Steering the content of individual projects
B	Coordination between projects
C	Strategic portfolio management

Monitoring
Within this focus area, no changes are made to the capabilities. Table 29 shows the capabilities for the focus area 'Monitoring'.

Table 29: Capabilities of the focus area 'Monitoring'

Capability	Description
A	Reactive monitoring
B	Active monitoring
C	Fully incorporated monitoring

Quality assurance
Within this focus area, no changes are made to the capabilities. Table 30 shows the capabilities for the focus area 'Quality assurance'.

Table 30: Capabilities of the focus area 'Quality assurance'

Capability	Description
A	Explicit quality review
B	Quality assurance process has been set up
C	Fully incorporated quality assurance policy

Management of the architectural process
Within this focus area, no changes are made to the capabilities. Table 31 shows the capabilities for the focus area 'Management of the architectural process'.

Table 31: Capabilities of the focus area 'Management of the architectural process'

Capability	Description
A	Management is incidentally executed
B	Management procedures have been set up
C	Continuous process improvement

Management of the architectural products
Within this focus area, no changes are made to the capabilities. Table 32 shows the capabilities for the focus area ‘Management of the architectural products’.

Table 32: Capabilities of the focus area 'Management of the architectural products'

Capability	Description
A	Management is incidentally executed
B	Management procedures have been set up
C	Presence of a management policy

Commitment and motivation
Within this focus area, no changes are made to the capabilities. Table 33 shows the capabilities for the focus area ‘Commitment and motivation’.

Table 33: Capabilities of the focus area 'Commitment and motivation'

Capability	Description
A	Allocation of budget and time
B	Architecture is acknowledged as a management instrument
C	Architecture is acknowledged as a strategic issue

Implementation of the architectural role
Within this focus area, no changes are made to the capabilities. Table 34 shows the capabilities for the focus area ‘Implementation of the architectural role’.

Table 34: Capabilities of the focus area 'Implementation of the architectural role'

Capability	Description
A	Role has been recognised
B	Role has been detailed
C	Role is supported
D	Role is appreciated

Architectural method
Within this focus area, no changes are made to the capabilities. Table 35 shows the capabilities for the focus area ‘Architectural method’.

Table 35: Capabilities of the focus area ‘Architectural method’

Capability	Description
A	Ad hoc
B	Structural
C	Fully incorporated

Interaction and collaboration
Within this focus area, no changes are made to the capabilities. Table 36 shows the capabilities of the focus area ‘Interaction and collaboration’.

Table 36: Capabilities of the focus area 'Interaction and collaboration'

Capability	Description
A	Collaboration between architects
B	Involvement of stakeholders
C	Shared ownership

Architectural tools
Within this focus area, no changes are made to the capabilities. Table 37 shows the capabilities for the focus area ‘Architectural tools’.

Table 37: Capabilities of the focus area 'Architectural tools'

Capability	Description
A	Ad hoc and product-oriented
B	Structural and process-oriented
C	Integration of tools

Budgeting and planning
Within this focus area, no changes are made to the capabilities. Table 38 shows the capabilities for the focus area ‘Budgeting and planning’.

Table 38: Capabilities of the focus area 'Budgeting and planning'

Capability	Description
A	Ad hoc
B	Structural
C	Optimising

3.3.3 Determine dependencies

Now that the capabilities per focus area are established, the dependencies must be determined. The dependencies for the first 17 focus areas are already determined by van Steenbergen et al. (2007). To determine the dependencies of the capabilities of the focus areas ‘Interoperability’ and ‘Utilisation of ZiRA models’, we must state the prerequisites per capability (van Steenbergen, Bos, et al., 2010). Table 39 shows the prerequisites for the capabilities of the focus area ‘Interoperability’.

There has to be a level of commitment and motivation in order to accommodate an ad hoc interoperability. Therefore, capability A is needed from the focus area ‘Commitment and motivation’. To get to a collaborative level of interoperability, with the help of recognised frameworks, a basis is needed. Capability A from ‘Architectural method’ specifies that specific architectural methods are used in specific cases. Using recognised frameworks for a collaborative level of interoperability is one of those specific cases. In an integrated level of interoperability, shared value systems and shared goals are important. It is therefore also important that there is some alignment with the hospital’s business strategy. So, capability A from ‘Alignment with business strategy’ is a prerequisite for capability C of ‘Interoperability’. Logically, all the previous capabilities within the focus area are prerequisites for the next.

Table 39: Prerequisites for the capabilities of focus area 'Interoperability'

Capability	Description	Prerequisite
A	Ad hoc	Capability A from ‘Commitment and motivation’
B	Collaborative	Capability A from ‘Interoperability’ and capability A from ‘Architectural method’
C	Integrated	Capability B from ‘Interoperability’ and capability A from ‘Alignment with business strategy’
D	Unified	Capability C from ‘Interoperability’

The prerequisite capabilities of the focus area ‘Utilisation of ZiRA models’ are as follows: Capability A has the prerequisite of capability A from ‘Architectural method’. There has to be an ad hoc architectural method, in this case working with the ZiRA in the first place before there can be an ad hoc utilisation of its models. The same goes for the other capabilities, they need to have the corresponding capability from ‘Architectural method’ before the capability can be obtained. Table 40 shows the prerequisite capabilities for the focus area ‘Utilisation of ZiRA models’.

Table 40: Prerequisites for the capabilities of focus area 'Utilisation of ZiRA models'

Capability	Description	Prerequisite
A	Ad hoc	Capability A from 'Architectural method'
B	Structural	Capability A from 'Utilisation of ZiRA models' and capability B from 'Architectural method'
C	Fully incorporated	Capability B from 'Utilisation of ZiRA models' and capability C from 'Architectural method'

3.3.4 Position capabilities in the matrix

With the dependencies from the previous chapter, the capabilities can be positioned in the matrix. Capabilities that have other capabilities as a prerequisite are positioned to the right of that capability. Furthermore, it is important to make sure that the capabilities are spread among the different maturity scales to get a more balanced matrix (van Steenbergen, Bos, et al., 2010). With these rules of thumb, we positioned the new capabilities in the matrix, resulting in the matrix shown in Figure 13.

#	Focus Area	0	1	2	3	4	5	6	7	8	9	10	11	12
1	Development of architecture		A			B			C					
2	Use of architecture			A			B				C			
3	Alignment with business strategy		A			B					C			
4	Alignment with realisation			A				B			C			
5	Relationship to the As-Is state					A				B				
6	Responsibilities and authorities				A		B					C		
7	Alignment with change portfolio				A				B		C			
8	Monitoring				A		B		C					
9	Quality assurance								A		B		C	
10	Management of the architectural process							A		B		C		
11	Management of the architectural products					A			B					C
12	Commitment and motivation		A					B		C				
13	Implementation of the architectural role				A		B		C				D	
14	Architectural method				A					B			C	
15	Interaction and collaboration			A		B				C				
16	Architectural tools							A				B		C
17	Budget and planning					A						B		C
18	Interoperability			A			B			C			D	
19	Utilisation of ZiRA models					A					B			C

Figure 13: The first version (0.1) of the enterprise architecture maturity matrix for hospitals

3.4 Developing the instrument

After the positioning of the capabilities, we have a first version of the enterprise architecture maturity matrix for hospitals. To use the matrix however, we need an assessment instrument. Therefore, the next steps in developing a functioning focus area maturity matrix are to develop the assessment instrument and define improvement actions as described by van Steenbergen, Bos, et al. (2010). Like with the DyAMM, the assessment instrument is based upon the checkpoints per capability. This subchapter elaborates on the checkpoints and suggestions for improvement of the enterprise architecture maturity model for hospitals.

3.4.1 Defining the checkpoints

Most of the checkpoints of the original focus areas of the DyAMM are unchanged in this matrix. Some of them were changed to tailor these checkpoints more towards hospitals. We changed the checkpoints where 'the organisation' was mentioned in the checkpoint to 'the hospital'. Since all the checkpoints of the DyAMM are presented in Appendix B, we do not repeat them here. The changed checkpoints, however, are presented in Table 41, showing which of the original checkpoints were changed. In total, 29 of the 136 original checkpoints were changed.

Table 41: Original checkpoints from the DyAMM that have been changed

#	Focus Area	Level	Checkpoint
3	1	A	The architecture addresses issues that are relevant to the hospital
9	1	C	An effective form of requirement management is in place for all constituent architectures relevant to the hospital
10	1	C	The architecture covers the relevant segments of the hospital (i.e. those segments for which it is desirable to have direction)
13	2	A	The architecture offers a clear picture of what the hospital wants.
18	2	C	Architecture plays an integral role in the hospital's decision-making process
45	6	A	The responsibility for the content of the architecture as a whole has been explicitly assigned to someone in the hospital.
47	6	A	The content of the architecture has an official status within the hospital.
48	6	B	The hospital has a body where decisions relating to the architecture can be taken (an architecture board, for instance).
49	6	B	The responsibility for the architectural process as a whole has been explicitly assigned to someone in the hospital.
53	7	A	The architecture is used as a guideline within individual projects for making design choices that are in line with the other developments within the hospital.
69	9	B	The hospital pays structural attention to the quality of the architecture.
70	9	B	The hospital has set up a quality assurance programme for the architecture.
71	9	C	The quality of the architecture is part of a general hospital-wide quality assurance policy.
72	9	C	The hospital pays structural attention to the effect of the architectural practice (examining, for example, to which extent having an architectural practice contributes to the achievement of its strategic and business objectives).
73	9	C	When thinking about architecture in terms of quality, the relationship between architecture and the other processes within the hospital is taken into account (e.g. strategy formation processes, development processes and by assigning responsibility for the quality assurance to an audit service).
76	10	A	The hospital is acquainted with the architectural process.
77	10	A	It is occasionally checked whether the architectural process still meets the hospital's needs.
79	10	B	Responsibility for the management of the architectural process has been assigned within the hospital.
88	11	B	The hospital has a procedure for dealing with change proposals for architectural products.
92	11	C	The hospital differentiates between how different components of the architecture are managed.
99	13	A	The role of architect exists within the hospital.
100	13	A	The architects can explain the architecture's added value for the hospital.
107	13	D	The hospital has an educational plan for architects.
108	13	D	The hospital has a career path for architects.
111	14	B	There is a shared architectural method within the hospital.
120	15	B	The hospital's employees have a genuine interest in the architecture.
121	15	B	The architects effectively communicate with the hospital regarding relevant developments in the architectural area.
122	15	B	The architects enjoy sufficient visibility and credibility within the hospital.
127	16	B	Responsibility for the management of the architectural tools has been explicitly assigned within the hospital.

The new focus areas with their capabilities need new checkpoints. At this stage, the knowledge from the ZiRA proofed to be beneficial. As mentioned earlier, the principles from the ZiRA have a similar structure as the checkpoints and capabilities. Most of the checkpoints we developed for the focus area 'Interoperability', we drew from the principles from the ZiRA. As for the checkpoints of the focus area 'Utilisation of ZiRA models', we drew the checkpoints from similar checkpoints of the DyAMM which also focus on the product domain. 8 of the 10 checkpoints of the focus area 'Interoperability' derived from principles from the ZiRA whereas two checkpoints were based on similar checkpoints of the DyAMM. All of the five checkpoints of the focus area 'Utilisation of ZiRA models' derived from similar

checkpoints of the DyAMM. Table 42 shows the new checkpoints and where they derived from for the new focus areas of the enterprise architecture maturity matrix for hospitals.

Table 42: Checkpoints for the new focus areas 'Interoperability' and 'Utilisation of ZiRA models'

#	Focus Area	Level	Derived from	Checkpoint
137	18	A	ZiRA principle	Agreements on interoperability have been made between involved care institutions.
138	18	A	Checkpoint 117	The architects from involved care institutions do not hesitate to get in touch with one another.
139	18	B	ZiRA principle	Message exchange between involved care institutions is based on standards (HL7 CDA, HL7 FHIR).
140	18	B	ZiRA principle	Clear agreements are made on which kind of data is exchanged with involved care institutions.
141	18	B	ZiRA principle	The hospital is connected to the Dutch national switch point (LSP).
142	18	C	ZiRA principle	Exchange of information with involved care institution is based on the specification of standard care information concepts.
143	18	C	Checkpoint 121	The architects from involved care institutions effectively communicate with each other regarding relevant developments in the architectural area.
144	18	C	ZiRA principle	The hospital is affiliated with MedMij.
145	18	D	ZiRA principle	Systems store and share information only based on the specification of standard care information concepts.
146	18	D	ZiRA principle	Systems are integrated throughout the ecosystem
147	19	A	Checkpoint 110	The architects are familiar with the models from the ZiRA.
148	19	A	Checkpoint 109	Models from the ZiRA are used as inspiration for the hospital's models.
149	19	B	Checkpoint 41 & 112	The architectural models of the hospital can be linked to the principles and metamodel of the ZiRA.
150	19	B	Checkpoint 113	When developing architectural models, models from the ZiRA are used as a basis and deviations are substantiated.
151	19	C	Checkpoint 115	All models from the ZiRA are integrated into the architectural models of the hospital.

3.4.2 Defining suggestions for improvement

In the DyAMM, there is at least one suggestion for improvement per capability. For the new capabilities in the new focus areas, new suggestions for improvement must be created. But first, we handle the suggestions for improvement that originate from the DyAMM. The full list of suggestions for improvement that originate from the DyAMM is presented in Appendix C. Again, some of these are changed to tailor them more towards hospitals by replacing ‘the organisation’ with ‘the hospital’. The suggestions of improvement that originate from the DyAMM and are changed are the following: 6, 9, 13, 16, 22, 32, 43, 45, 48, 56, 60, 61, 64, 65, 70, 71, 76, 79, and 82.

The creation of the suggestions for improvement of the new focus areas is based on the same foundation as the new checkpoints. The checkpoints are based on derivated principles of the ZiRA or an original checkpoint. The same goes for the suggestions for improvement. Four suggestions for improvement derived from original suggestions for improvement of the DyAMM. Four suggestions derived from principles of the ZiRA, whereas one suggestion derived from both a principle as an original suggestion. Table 43 shows the suggestions for improvement for the new focus areas of the enterprise architecture maturity matrix for hospitals.

Table 43: Suggestions for improvement for the new focus areas ‘Interoperability’ and ‘Utilisation of ZiRA models’

#	Focus Area	Level	Derived from	Suggestion for improvement
84	18	A	Suggestion for improvement 72	Organise interaction. Make sure that you come in contact with architects from other healthcare organisations. Get in contact with these architects and make arrangements about information exchange.
85	18	B	ZiRA principle	Make arrangements about standards. Internally and externally, arrangements should be made about which information is exchanged. Make sure that you make these arrangements are based on established standards

86	18	B	ZiRA principle	Connect to the LSP. To connect to the LSP the following three matters should be in order: 1) A well managed healthcare system, 2) A well managed healthcare network, and 3) UZI-resources. Get these matters in order and start with the connection process.
87	18	C	ZiRA principle & Suggestion for improvement 76	Expand collaboration. Build on the arrangement already made with the healthcare organisations and make sure that the information exchanged with them is based on standard healthcare information concepts. Get involved in a community of architecture in healthcare and make sure that relevant developments are on the agenda.
88	18	C	ZiRA principle	Take part in MedMij. Check the arrangements of MedMij and make sure that you fulfil to these arrangements. When you are aligned with the arrangements, apply for taking part in the MedMij arrangement system.
89	18	D	ZiRA principle	Implement an integral system. Check whether one of your existing systems is fit for making it integral throughout the ecosystem. Get in contact with the stakeholders in the ecosystem and make arrangements to implement an integral system. It is important that everyone in the ecosystem supports this system.
90	19	A	Suggestions for improvement 68 & 69	Get acquainted with the ZiRA. Take a look at the models in the ZiRA and make sure that the architects are acquainted with them. Know which models there are in the ZiRA and what the scope of them is. Take a look at the ZiRA for inspiration of your own architectural products
91	19	B	Suggestion for improvement 70	Check common ground with the ZiRA. Compare the architectural products of the hospital with the principles of the ZiRA. Try to make your products adhere to these principles.
92	19	C	Suggestion for improvement 71	Perform assessment. Check the models of the ZiRA and make sure these are represented in the architectural products of the hospital. Follow updates of the ZiRA closely and share your best-practices with the ZiRA community.

3.5 Conclusion

In this chapter we describe how the first version of the enterprise architecture maturity model for hospitals is designed. The DyAMM is introduced and its components are modelled in a meta-model. A meta-model is also drawn up for the ZiRA. We then applied a lens on both the meta-models which shows which components from the DyAMM and the ZiRA can be integrated.

We executed the method described by van Steenbergen, Bos, et al. (2010) to actually change the DyAMM. By taking the requirements into account, two new focus areas derive to complement the DyAMM. With the addition of the focus area ‘Interoperability’ and ‘Utilisation of ZiRA models’, a total of 19 focus areas exist for the first version of the model. An existing maturity model about interoperability showed to be a good input for the capabilities of the focus area ‘Interoperability’. The capabilities of the focus area ‘Utilising ZiRA models’ were mostly inspired by the existing capabilities of the DyAMM. To position the new capabilities of the new focus areas in the matrix, we devised dependencies. Through logically reasoning which existing capabilities are needed before the new capabilities can and should be achieved, these dependencies arose. The rules of thumb from the method assisted in positioning the capabilities in the matrix. The result is version 0.1 of the enterprise architecture maturity model for hospitals, presented in Figure 13.

When developing the assessment instrument, the principles from the ZiRA showed to be good candidates for integration. 8 of the 15 new checkpoints and 5 of the 9 new suggestions for improvement derived from ZiRA principles. The others were based on checkpoints and suggestions for improvement from the ZiRA which encompass the same domain.

It is important to check whether the design fulfils the requirements from the experts. Table 44 shows the functional requirements from Table 13 and whether and how these are fulfilled. The next step in the design cycle is treatment validation, which is elaborated in the next chapters.

Table 44: Requirements fulfilled by the first design

#	Requirement	Fulfilled
1	The model should evaluate the maturity level	Yes
2	The model should give suggestions for improving the maturity level	Yes

3	The model should incorporate parts of the ZiRA	Yes, new focus area
4	The model should have more than six maturity levels	Yes, a total of 12
5	The model should have multiple focus areas	Yes, a total of 19
7	The model should evaluate whether the enterprise architecture is based on standard information concepts	Yes, checkpoints 142 and 145
11	The model should evaluate the processes involved around the enterprise architecture	Yes, focus area 10
12	The model should evaluate whether the hospital is interoperable in the ecosystem	Yes, new focus area
13	The model should evaluate whether the as-is enterprise architecture is modelled	Yes, focus area 5
14	The model should evaluate which tools you are using	Yes, focus area 16

4. Focus group sessions

This chapter describes the treatment validation, in specific the ex ante naturalistic evaluation of the design of the enterprise architecture maturity model for hospitals. As described in chapter 1.2, the treatment validation consists of focus group sessions and case studies. The case studies are elaborated in chapter 6, this chapter focuses on the focus group sessions. Two focus group sessions are executed to evaluate the design. In short, the first session is directed to the semantics of the design, whereas the second session concentrates on the syntax of the design. The first subchapter elaborates on the first focus group session, whereas the second subchapter describes the second one. The third subchapter encompasses the validity of both the focus group sessions. Finally, the conclusions are drawn in the last subchapter.

4.1 First focus group session

The first focus group session took place on 4 March 2019 in a meeting room of Sogeti in Amersfoort. This subchapter describes 1) the approach of the focus group session, 2) the execution of the focus group session, and 3) the results of the focus group session.

4.1.1 Approach

To use focus group sessions for evaluating the design of the enterprise architecture maturity model, first, we have to define a number of key design concepts: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group (Morgan, 1996).

The goal of the first focus group session is to gain consensus on whether the participants think the changes and additions made to the original model are relevant for assessing the enterprise architecture maturity of a hospital. This concerns the semantics of the maturity model. We establish the following research question for the first focus group session:

RQ: Do the participants agree that the additions made to the original model are relevant for assessing the enterprise architecture of a hospital?
With this question, we try to answer whether the adjustments we made to the original model have added value specifically for hospitals according to the participants.

The selection of participants is completed from a community of architects that work in the healthcare domain. We recruit the participants through an open invite with selection criteria. We define the selection criteria as follows: they should be professionals that have worked with architecture in the healthcare domain for at least three years. The main researcher is the facilitator of the focus group. At the start of the focus group session, the facilitator asks the participants if they allow him to record the session. If that is the case, the session is recorded with a mobile phone, otherwise, someone is asked to write minutes of the session. This raw audio recording is then transcribed. The transcript is coded in NVivo. We present the protocol of the first focus group session in Table 45. A visual presentation of the protocol in BPMN is presented in Figure 14.

Table 45: Protocol first focus group session

Activity	Description
Preparation	Print out the maturity model for hospitals on A3 paper and bring sufficient post-its, papers, and pens. Also, make sure that the chairs and tables are set up in a U-shape. The room must have a working beamer or screen. The A3 papers with the model on it should be placed on the wall beforehand. There should be a nice environment during the focus group session. Therefore, there should be access to coffee and tea. It would also be nice if there are some snacks for the participants.
Introduction	Introduce the facilitator, and the research, especially the objectives of this focus group session. It is important to introduce that this is a scientific evaluation, and that sometimes strict rules are enforced in the process. Also, initiate a quick introduction among the participants.

Presentation of the model	Present the enterprise architecture maturity model to the participants and emphasise on the adjustments made to tailor it towards hospitals.
Post-it session	1. For every new component compared to the original model, let participants write on a post-it what their opinion concerning the relevance of that component is. This is completed before starting the discussion to make sure that everyone is able to give their unaffected opinion. Give the participants the following choices: a. Positive about the addition b. Negative about the addition c. No opinion about the addition 2. Collect the post-its and place them on the corresponding component on the wall. 3. Have a discussion about the component when not all the post-its are positive. The goal of this discussion is to gain consensus about the component. 4. Repeat steps 1 through 3 for every new component.
Ending	Thank the participants and announce how the results will be published.

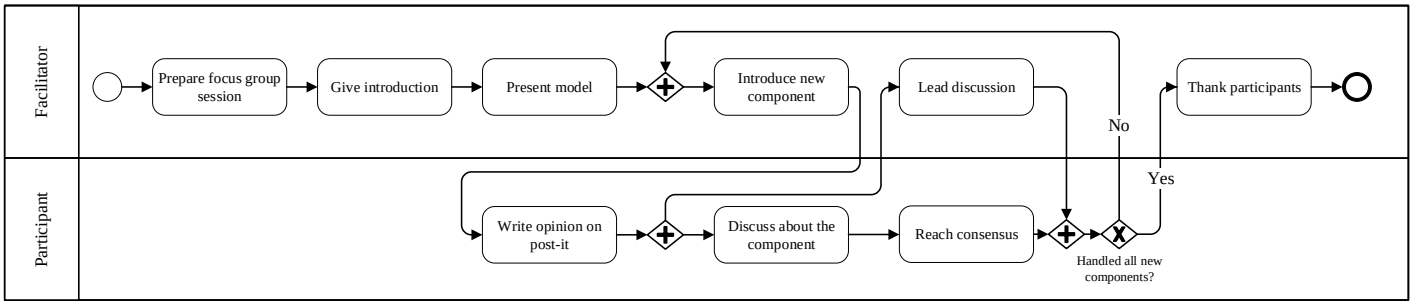

Figure 14: Protocol first focus group session in BPMN

4.1.2 Execution

We described selection criteria in an open invitation for the participants. The selection criterium was that the participants should be professionals that have worked with architecture in the healthcare domain for at least three years. Table 46 shows the working experience of the seven participants in the first focus group session.

Table 46: Participants of the first focus group session

Participant	Years in healthcare	Architecture experience	The organisation they work for
1	2	Business analysis/information architecture	Consultancy firm
2	0	Architecture in financial domain	Freelance
3	8	Enterprise architecture	National health care institute
4	25	Information architecture	Academic hospital
5	10	Information architecture	Oncological and palliative quality institute
6	5	Solution architecture	Healthcare IT provider
7	20	Health data architecture	Health data management

Despite describing the selection criteria in the invite, some participants did not meet them. Participant 2 called the facilitator up front to ask whether he was allowed to join without meeting the criteria. This was allowed because the participant had experience in architecture but not in healthcare and might be able to shed light from a different perspective. It was agreed that this participant would hold back during the discussion. Participant 1 does not meet the criteria either. With this participant, there was no communication beforehand. However, he also held back during the discussion. Another consideration to include these participants into the session was that including non-typical participants in the focus group sessions helps reducing researcher bias (Miles & Huberman, 1994).

The meeting room was prepared according to the protocol, as shown in Figure 15. The tables for the participants were set-up in a U-shape, there was a working presentation screen, the model was printed

on A3 and placed on the wall, there were sufficient post-its and pens on the table, and there were some snacks and enough coffee and tea for the participants. There was a nice environment for the participants.

Figure 15: Preparation of the first focus group session

Figure 14 and Table 45 describe the first focus group session protocol. The session did not completely follow this protocol. After handling the new focus area and its capabilities, it became clear that there was not enough time to handle every new component this extensive. Therefore, the facilitator decided together with the participants to handle the new checkpoints and suggestions for improvement less extensively. During the discussion about the capabilities, the participant also noticed subjects for discussion in the checkpoints and suggestions for improvement. Instead of handling the checkpoints and suggestions for improvement separately per component, the participants were asked which checkpoints and suggestions they wanted to discuss. All the checkpoints and suggestions for improvement that were mentioned by the participants were discussed and the participants reached a consensus during these discussions.

Because the facilitator noticed that the protocol took too long and decided to change it, all the additions to the DyAMM were handled. The two new focus areas and the seven capabilities were handled following the protocol in Figure 14. The fourteen new checkpoints and nine new suggestions for improvement were handled in a less extensive manner. They were not handled separately. Instead, the participants decided which checkpoints and suggestions for improvement they wanted to discuss.

4.1.3 Results

The focus group was recorded and transcribed. In NVivo we analysed these transcripts. We decided to code the transcripts into nodes. For both the new focus areas, a node was created. Underneath these nodes, child nodes were created for the capabilities within the focus group and checkpoints and suggestions for improvement. The taxonomy of the nodes is based on the meta-model of the DyAMM. Figure 16 shows a screenshot of the coding of the transcript in the node taxonomy.

Name	Files	References
Focus group	1	17
Focus area 18	1	13
Capability	1	12
Checkpoint	1	5
Suggestion for improv	1	1
Focus area 19	1	4
Capability	1	3
Checkpoint	0	0
Suggestion for improv	0	0

Figure 16: Screenshot of the coding in NVivo of the transcript of the first focus group session

Every conclusion where consensus was reached is coded under the corresponding part of the new focus areas. None of the checkpoints or suggestions for improvement of focus area 19 were discussed in the focus group session since the participants did not bring these up for discussion. There was more discussion on focus group 18 ‘Interoperability’ then on the other focus area, indicated by the number of references at the nodes.

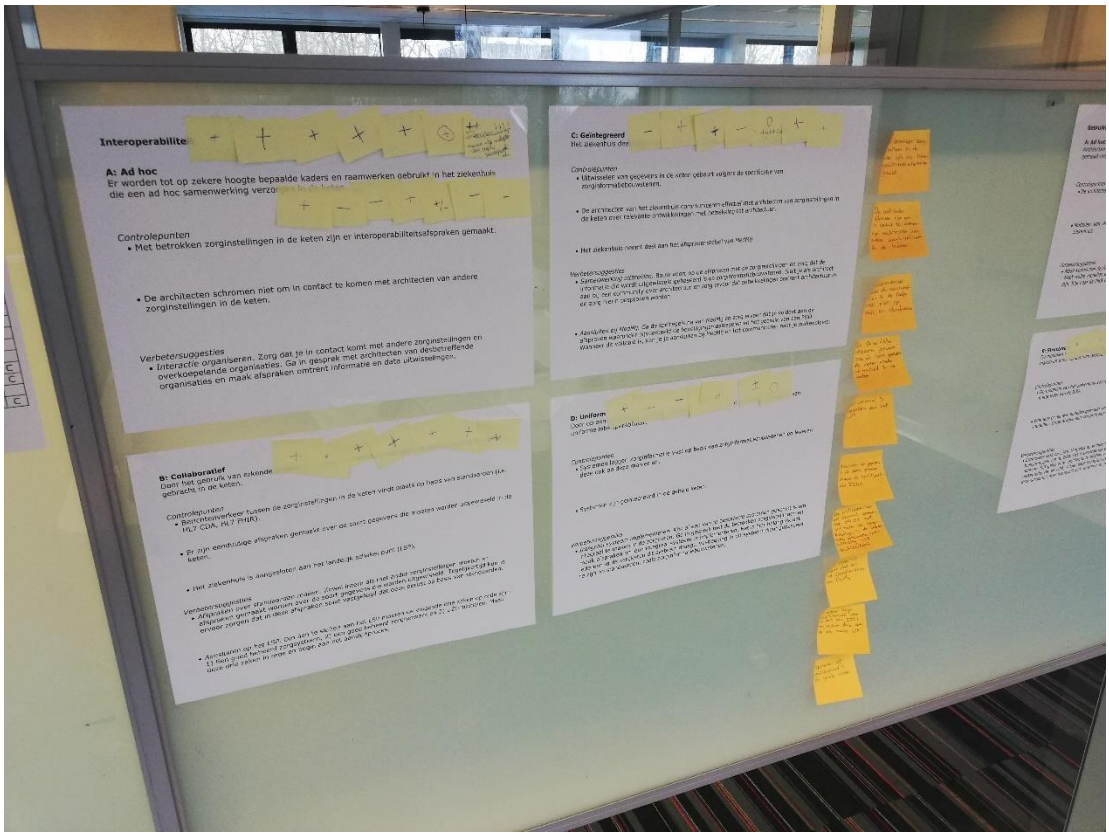

Figure 17: Post-its from the first focus group sessions on focus area 'Interoperability'

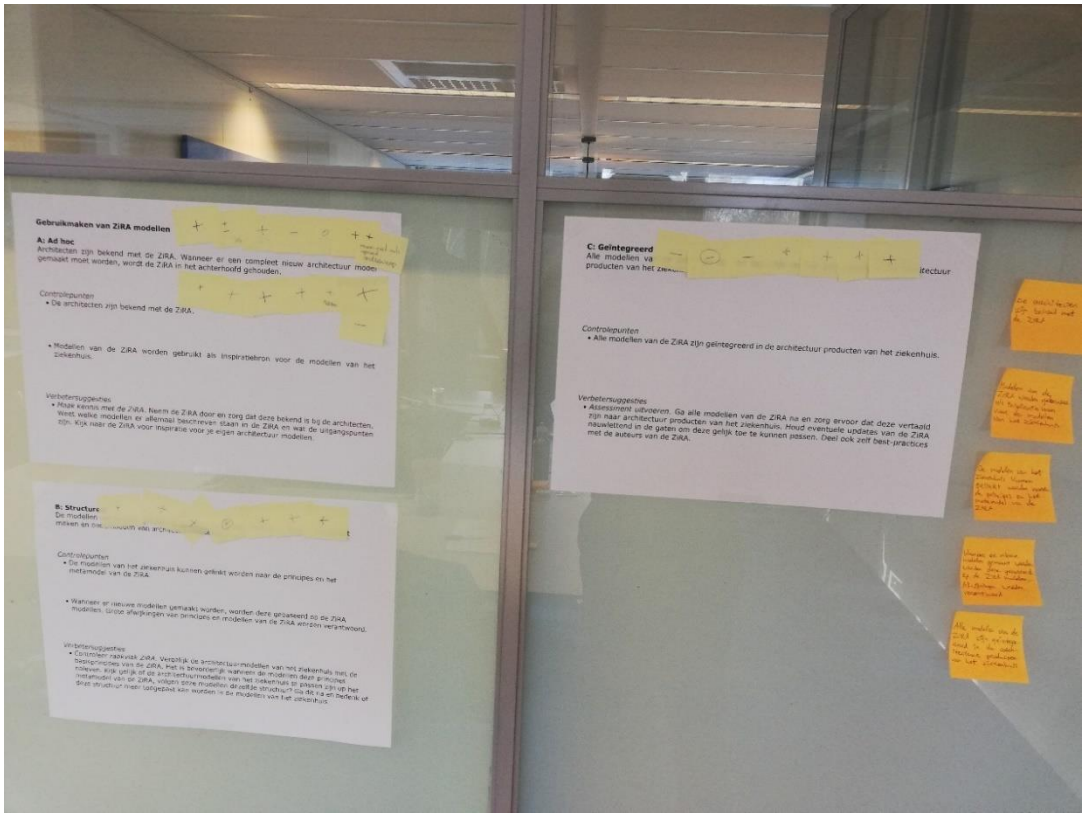

Figure 18: Post-its from the first focus group session on focus area 'Utilisation of ZiRA models'

Figure 17 and Figure 18 show the result of the post-its with the opinions of the participants per focus area and capability. In Table 47 we show how many positive, negative, and 'no-opinion' post-its there were per focus area and capability.

Table 47: Number of post-its per treated part of the model of the first focus group session

Part of the model	Nr. of positives	Nr. of negatives	Nr. of 'no-opinions'
Focus area 18 'Interoperability'	7	0	0
Capability A from focus area 18	2	4	1
Capability B from focus area 18	7	0	0
Capability C from focus area 18	4	2	1
Capability D from focus area 18	1	3	3
Focus area 19 'Utilisation of ZiRA models'	4	1	2
Capability A from focus area 19	6	1	0
Capability B from focus area 19	7	0	0
Capability C from focus area 19	4	3	0

Following protocol, the parts that only received positive post-its were not discussed. This goes for focus area 18, capability B from focus area 18, and capability B from focus area 19. Table 48 shows what the consensus was for each part of the model that was discussed.

Table 48: Consensus from the discussions about the focus areas and capabilities

Part of the model	Consensus
Capability A from focus area 18	The name stays 'Ad hoc' but change the description.
Capability C from focus area 18	The name stays 'Integrated' but change the description.
Capability D from focus area 18	Change the name to 'Integral' and change the description.
Focus area 19 'Utilisation of ZiRA models'	Change the name to 'Utilisation of best-practices' and change the description. Also, replace 'ZiRA Models' with 'best-practices' in the remainder of the focus area.
Capability A from focus area 19	The name stays 'Ad hoc' but change the description.
Capability C from focus area 19	Change the name to 'Embedded' and change the description.

Whenever the description was changed in one of the parts of the model, this change was also suggested for the underlying parts of the model. For example, the description of capability C from focus area 18 is changed from the scope 'involved healthcare organisations' to 'all stakeholders in the ecosystem'. This change of scope is then also extended for the checkpoints and suggestions for improvement in capability C.

After the focus areas and capabilities were discussed, the participants were asked which checkpoints and suggestions for improvement they wanted to discuss. Table 49 shows which checkpoints and suggestions for improvement were discussed and what the consensus was in the discussion.

Table 49: Consensus from the discussions about the checkpoints and suggestions for improvement

Part of the model	Consensus
New checkpoint	There should be new checkpoint under capability D from focus area 18
Checkpoint 141	Remove this checkpoint
Checkpoint 144	Remove this checkpoint
New checkpoint	There should be a new checkpoint under capability B from focus area 18
Checkpoint 142	Change the checkpoint to make it more generic
Suggestion for improvement 86	Remove this suggestion for improvement
Suggestion for improvement 88	Remove this suggestion for improvement

In total, one focus area, five capabilities, and one checkpoint were changed. Two new checkpoints derived, whereas two checkpoints and two suggestions for improvement were removed. This is excluding the small changes in the naming in the descriptions of the checkpoints and suggestions for improvement. These changes resulted in version 0.2 of the enterprise architecture maturity matrix for hospitals. The new focus areas 'Interoperability' and 'Utilisation of best-practices' with their capabilities are depicted in respectively Table 50 and Table 51. The last column shows whether the part is changed or not.

Table 50: Capabilities focus area 'Interoperability' after the first focus group session

Capability	Name and description	Changed?
A	Ad hoc. Frameworks are incidentally used which allow for ad hoc interoperability arrangements	Yes
B	Collaborative. Recognised frameworks are in place to support collaborative interoperability	No
C	Integrated. Shared information services and shared goals on all layers provide integrated interoperability	Yes
D	Integral. Interoperating by design on a continuing basis makes an integral interoperability	Yes

Table 51: Capabilities focus area 'Utilisation of best-practices' after the first focus group session

Capability	Name and description	Changed?
A	Ad hoc. When making a new architectural product, best-practices are occasionally utilised.	Yes
B	Structural. Best-practices are structurally utilised when making and managing architectural products.	Yes
C	Embedded. Best-practices are embedded in managing the architectural products	Yes

The checkpoints as derived after the first focus group session are presented in Table 52. The suggestions for improvement as derived after the first focus group sessions are presented in Table 53. Here again, the last column shows whether the checkpoint or suggestion for improvement is changed.

Table 52: Checkpoints after the first focus group session

#	Focus Area	Level	Checkpoint	Changed?
137	18	A	Agreements on interoperability have been made with stakeholders in the ecosystem	Yes
138	18	A	The architects from involved care institutions do not hesitate to get in touch with one another.	No
139	18	B	Information exchange with other healthcare organisations is based on established standards (HL7 CDA, HL7 FHIR)	Yes
140	18	B	Clear agreements are made on which kind of data is exchanged with stakeholders in the ecosystem	Yes
141	18	B	The hospital participates in agreement systems for the healthcare domain (e.g. MedMij)	Yes, new
142	18	C	Information exchange with all stakeholders in the ecosystem is based on established standards	Yes
143	18	C	The architects from involved healthcare organisations effectively communicate with each other regarding relevant developments in the architectural area.	No
144	18	D	Systems store and share information only based on established standards	Yes
145	18	D	Systems are integrated cross-sector throughout the ecosystem	Yes
146	18	D	The hospital is interoperable by design	Yes, new
147	19	A	The architects are familiar with relevant best-practices (e.g. the ZiRA)	Yes
148	19	A	Best-practices are used as inspiration for the hospital's architectural products	Yes
149	19	B	The architectural products of the hospital can be linked to best-practices	Yes
150	19	B	When developing architectural products, best-practices are used as a basis and deviations are substantiated	Yes
151	19	C	All relevant best-practices are embedded in the architectural products of the hospital	Yes

Table 53: Suggestions for improvement after the first focus group session

#	Focus Area	Level	Suggestion for improvement	Changed?
84	18	A	Organise interaction. Make sure that you come in contact with architects from other healthcare organisations. Get in contact with these architects and make arrangements about information exchange.	No
85	18	B	Make arrangements about standards. Internally and externally, arrangements should be made about which information is exchanged. Make sure that you make these arrangements are based on established standards	No
86	18	C	Expand collaboration. Build on the arrangement already made with the healthcare organisations and expand to all stakeholders in the ecosystem. Make sure that the information exchanged with them is based on established standards. Get involved in a community of architecture in healthcare and make sure that relevant developments are on the agenda.	Yes
87	18	D	Implement an integral system. Check whether one of your existing systems is fit for making it integral throughout the ecosystem. Get in contact with the stakeholders in the ecosystem and make arrangements to implement an integral system. It is important that everyone in the ecosystem supports this system.	No
88	19	A	Get acquainted with the best-practices in healthcare. Take a look at them and make sure that the architects are acquainted with them. Know which best-practices there are and what the scope of them is. Take a look at relevant best-practices for inspiration for your own architectural products	Yes
89	19	B	Check common ground with the best-practices. Compare the architectural products of the hospital with best-practices. Try to make your products adhere to these best-practices.	Yes
90	19	C	Perform assessment. Check the relevant best-practices and make sure these are represented in the architectural products of the hospital. Follow updates of relevant best-practices closely and share your experiences with the community.	Yes

4.2 Second focus group session

The second focus group session took place on 29 March 2019 in a meeting room of Sogeti in Vianen. This subchapter describes 1) the approach of the focus group session, 2) the execution of the focus group session, and 3) the results of the focus group session.

4.2.1 Approach

The goal of the second focus group session is to gain consensus on whether the participants think that the changes made to the original model are syntactically correct. We establish the following research questions for the second focus group session:

RQ: Do the participants agree that the additions to the DyAMM are syntactically correct, keeping the vision and goal of the DyAMM in mind?
By answering this question, we gain insight into whether the additions we made are correct. Correct in the sense of syntax, whether the changes made to the model fit in the syntax of the model. This also provides an answer on whether the changes are made on the correct granularity level of the original model.

The selection of participants is completed among experts in (using the) the original model. It is required that the participants should have extensive knowledge of the original model, translated in at least 5 years of experience in working with the model. This second focus group session is facilitated by the main researcher as well. The information recording facilities are the same as with the first focus group session. The participants are asked if they allow audio recording of the session. This raw audio recording is then transcribed. The transcript is coded in NVivo. We present the protocol of the second focus group session in Table 54. A visual presentation of the protocol in BPMN is presented in Figure 19.

Table 54: Protocol second focus group session

Activity	Description
Preparation	Print out the revised maturity model for hospitals on A3 paper and bring sufficient post-its, papers, and pens. The room must have a working beamer or screen. The A3 paper with the model on it should be placed on the wall beforehand. There should be a nice environment during the focus group session. Therefore, there should be access to coffee and tea.
Introduction	Introduce the facilitator, and the research, especially the objectives of this focus group session. It is important to emphasise that this is a scientific evaluation, and that sometimes strict rules are enforced in the process.
Presentation of the model	Present the enterprise architecture maturity model to the participants. The participants are already familiar with the DyAMM, so emphasise on the additions and changes made. Explain the process of how these additions and changes derived.
Post-it session 1	1. Ask the participants whether they think that new focus areas can be added to the DyAMM. This fundamental question is asked before discussing the additions, to distinguish between the main point of discussion and the side points of discussion which are the additions themselves. Before discussion though, let the participants write their opinion on post-its. This is completed before the discussion to make sure that everyone is able to give their unaffected opinion. Give the participants the following choices: a. Positive about adding new focus areas b. Negative about adding new focus areas c. No opinion about adding new focus areas 2. Collect post-its and place them on the wall 3. Have a discussion about this subject when not all the post-its are positive. The goal of this discussion is to come to a consensus about whether focus areas can be added to the DyAMM.
Post-it session 2	1. For every new focus area, ask the participants whether they think that the new focus area is distinct enough to be a new focus area instead of being integrated into one of the existing. Before the discussion, let them write their opinion on post-its. Give the participants the following choices: a. Positive, the focus area is distinct enough to be a new focus area

	b. Negative, the focus area does not deserve to be a new focus area and can be integrated into one of the existing focus areas c. No opinion about whether the focus area is distinct enough 2. Collect post-its and place them on the corresponding focus area 3. Have a discussion about the focus area when not all the post-its are positive. The goal of this discussion is to come to a consensus about whether the focus area should be a new focus area or that it should be integrated into an existing focus area. If the consensus is that the focus area should be integrated into an existing focus area, there should also be a consensus on how it should be integrated.
Discuss the position of capabilities	The capabilities of the new focus areas are placed in the matrix based on prerequisites and some rules of thumb. Discuss with the participants whether they agree with the positions of the capabilities in the maturity matrix. The goal of this discussion is to come to a consensus on the positions of the capabilities in the matrix.
Ending	Thank the participants and announce how the results will be published.

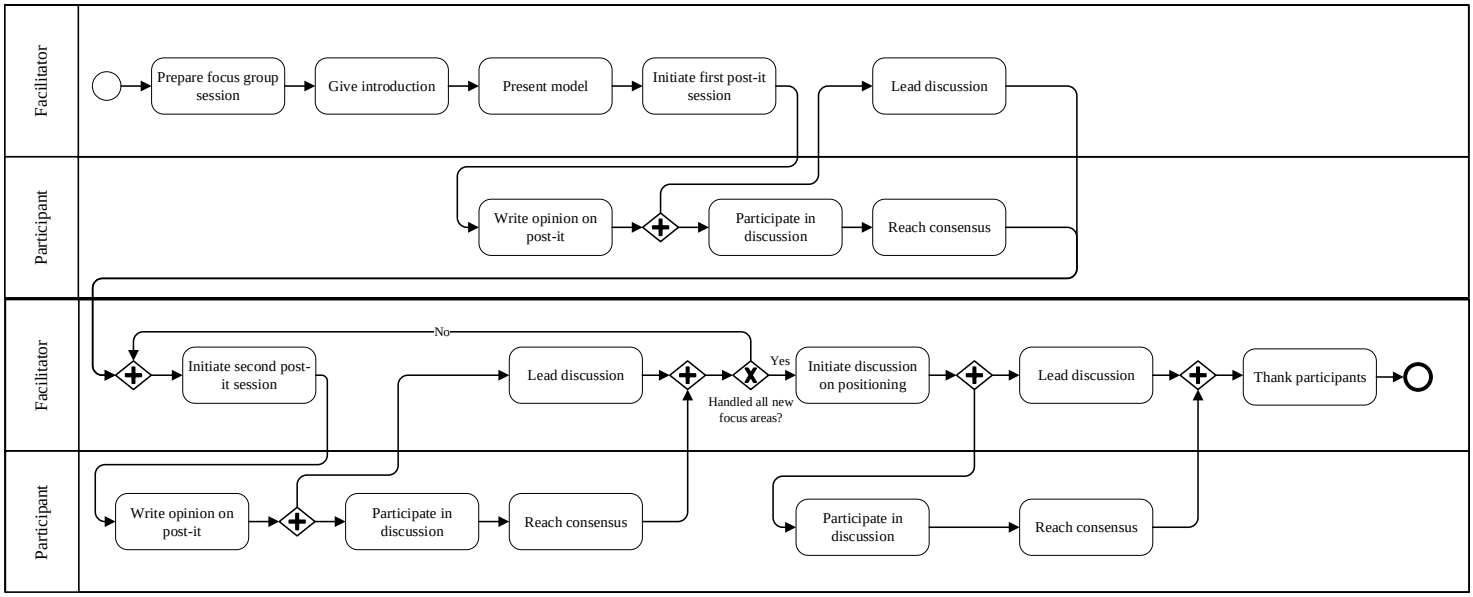

Figure 19: Protocol second focus group session in BPMN

4.2.2 Execution

The participants were selected amongst consultants from Sogeti, with the requirement that they have extensive knowledge of the DyAMM. Table 55 shows the working experience of the four participants in the second focus group session.

Table 55: Participants of the second focus group session

Participant	Years of experience with architecture	Years of experience with the DyAMM
1	25	17
2	15	6
3	24	13
4	26	8

All the participants met the requirement that they should have at least 5 years' experience with the DyAMM. Participant 1 and participant 3 are authors of the DyAMM, making them excellent participants for the syntactical validation of the enterprise architecture maturity model for hospitals.

The meeting room was prepared according to the protocol, as shown in Figure 20. There was a working presentation screen, the model was printed on A3 and placed on the wall, there were sufficient post-its and pens on the table, and there was enough coffee and tea for the participants. The room was located in the main office of Sogeti, making it a nice and comfortable environment for the participants, which are all consultants from Sogeti.

Figure 20: Preparation of the second focus group session

Table 54 and Figure 19 describe the second focus group session protocol. The session almost completely followed this protocol. All the steps in the protocol were executed. However, some discussion arose about the checkpoints of the enterprise architecture maturity model for hospitals. The results of the second focus group session, including the extra discussion about the checkpoints, are elaborated in the next subchapter.

4.2.3 Results

The focus group session was recorded and transcribed. In NVivo we analysed the transcripts. The transcripts are coded in the same nodes as from the first focus group session. Figure 21 shows a screenshot of the result of the coding after processing the second focus group session.

Name	Files	References
Focus areas	2	39
Focus area 18	2	29
Capability	2	25
Checkpoint	2	11
Suggestion for improv	1	1
Focus area 19	2	8
Capability	1	3
Checkpoint	0	0
Suggestion for improv	0	0

Figure 21: Screenshot of the coding in NVivo of the transcripts after the second focus group session

The consensus on the fundamental question of whether focus areas can be added to the DyAMM is coded under the main node ‘Focus areas’. The consensus from the second post-it session, about the new focus

areas themselves, are coded under node ‘Focus area 18’ and ‘Focus area 19’. The discussion and consensus about the positioning of the capabilities are coded under the node ‘Capability’ from the corresponding focus area. Figure 22 shows the result of the post-its with the opinions of the participants.

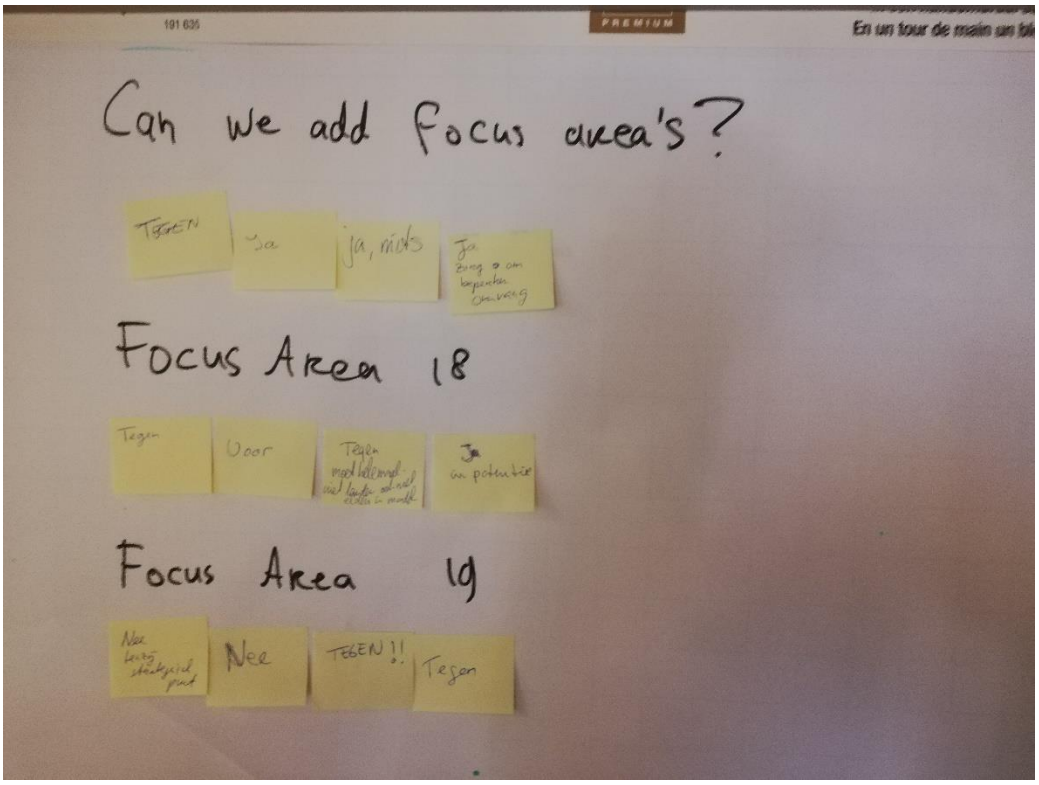

Figure 22: Post-its from the second focus group session

In Table 56 we show many positive, negative, and ‘no-opinion’ post-its there were per post-it session and focus area.

Table 56: Number of post-its per session for the second focus group session

Post-it session	Focus area	Nr. of positives	Nr. of negatives	Nr. of ‘no-opinions’
1		3	1	0
2	18	2	2	0
2	19	0	4	0

Following protocol, discussions were held on all the subjects, since none of them received merely positive post-its. The fundamental discussion on whether focus areas can be added was a short one. The one participant that gave a negative opinion was actually in favour but “wrote ‘against’ on the post-it because I was expecting all yesses and I wanted to have a discussion”. Shortly after this comment, a consensus was reached that it is possible to add focus areas to the DyAMM. However, the participants did place a footnote on this consensus. Every addition to the DyAMM should be critically reviewed and new focus areas should be mutually exclusive with the others.

During the discussion on focus area 18, an argument rose that the focus area could possibly be integrated into an existing focus area. However, a consensus was reached that the focus area is too different from this focus area and that it deserves to be a new focus area. Here a footnote was placed that the focus area should not be too much focussed on the content of architecture, but more on the process of participation in the ecosystem. This footnote mostly concerned on how the focus area should look like when it would be generalised towards all domains and it concerns the content of the focus area, which was out of scope for this focus group session. Therefore, the title and description of the focus area is not changed.

The discussion on focus area 19 was more briefly. All participants shared the opinion that the focus area should not be a separate focus area. They did agree with the rationale of this focus area and that it should be incorporated in the existing focus area. Eventually, a consensus was reached on incorporating the checkpoints from focus area 19 into the focus areas 'Development of architecture' and 'Architectural method'.

The result from the post-it sessions of the second focus group session is that focus area 19 is removed from the enterprise architecture maturity model for hospitals and that the checkpoints from this focus area are integrated into existing focus areas.

After the post-it sessions, the discussion about the position of the capabilities was initiated. Firstly, it was discussed in which stage each capability should be positioned. In the matrix, it is possible to distinguish 4 stages, when the maturity scale is at respectively 3, 6, 8, 10, and 12. The stages are as follows:

- Stage 3: a start is made on the employment of architecture. The most important focus areas are developed to a basic level. There is an awareness that architecture must be embedded into the organisation and work is being done on this matter
- Stage 6: nearly all the focus areas are developed to a basic level. Consideration is given to architecture as a process. Architectural practices are structurally established.
- Stage 8: architecture now facilitates the most important organisational changes. There is commitment throughout the organisation.
- Stage 10: architecture is used as an integral part of all the changes occurring in an organisation. Architectural practices are integral to the organisation.
- Stage 12: architectural practices are at such a high level of proficiency that architectural processes and products are continuously optimised.

Only focus area 18 was discussed during this discussion since it was decided that focus area 19 should be discarded. Firstly, a consensus was reached that capability A should be in stage 3 (scale 0-3), capability B should be in stage 6 (scale 4-6), capability C should be in stage 10 (scale 9 or 10), and capability D should be in stage 12 (scale 11 or 12).

Secondly, a consensus was reached on the dependency between the new capabilities and existing capabilities in other focus areas. Table 57 shows the consensus on the dependencies of the capabilities from focus area 18 and at which scale they are therefore positioned. The dependencies of capabilities A, B, and C were changed as a result of this discussion, whereas the position of B and C was also changed. There was consensus on keeping the dependency of capability D and keeping it on the same position since this keeps the matrix in balance. Figure 23 shows version 0.3 of the enterprise architecture maturity model for hospitals which is established based on the second focus group session.

Table 57: Dependencies of the capabilities from focus area 18 after the second focus group session

Capability	Scale	Dependency	Changed?
A	2	Capability A from 'Commitment and motivation' as a prerequisite and it should be on the same scale as capability A from 'Interaction and collaboration' because these should be handled parallelly.	Yes, the position not
B	6	Capability A from 'Interoperability' and capability A from 'Architectural method' as prerequisites. It should be on the same scale as capability B from 'Commitment and motivation' because these should be handled parallelly.	Yes, 5 → 6
C	9	Capability B from 'Interoperability', capability B from 'Alignment with business strategy', capability B from 'Relationship to the As-Is state', and capability C from 'Commitment and motivation' as prerequisites.	Yes, 8 → 9
D	11	Capability C from 'Interoperability' as a prerequisite.	No

#	Focus Area	0	1	2	3	4	5	6	7	8	9	10	11	12
1	Development of architecture		A			B			C					
2	Use of architecture			A			B				C			
3	Alignment with business strategy		A			B					C			
4	Alignment with realisation			A				B			C			
5	Relationship to the As-Is state					A				B				
6	Responsibilities and authorities				A		B					C		
7	Alignment with change portfolio				A				B		C			
8	Monitoring				A		B		C					
9	Quality assurance								A		B		C	
10	Management of the architectural process							A		B		C		
11	Management of the architectural products					A			B					C
12	Commitment and motivation		A					B		C				
13	Implementation of the architectural role				A		B		C				D	
14	Architectural method				A					B			C	
15	Interaction and collaboration			A		B				C				
16	Architectural tools							A				B		C
17	Budget and planning					A						B		C
18	Interoperability			A				B			C		D	

Figure 23: Version 0.3 of the enterprise architecture maturity matrix for hospitals

While discussing the positions of the capabilities of the new focus area, some discussion derived concerning the phrasing, content, and position of some checkpoints. As mentioned earlier, the participants shared the opinion that the new focus area should not be too technical and only focus on the content of the architecture. There was consensus on the fact that the new checkpoint should be more nuanced, i.e. saying that the architecture provides the opportunity to fulfil a checkpoint instead of demanding that something (technical) is achieved. Also, to make sure that the focus area is not merely based on technical checkpoints, they should also be based on the processes involving interoperability.

Another point of discussion concerning the checkpoints was about the position of checkpoints in capability B and C of the new focus area. It became clear during the discussion that some of the checkpoints in capability B are heavier than checkpoints in capability C. Consensus was reached that some of the checkpoints in capability B should be moved to capability C and vice versa.

The consensus on the phrasing, content, and position of checkpoints resulted in some changes in the checkpoints. Table 58 shows which checkpoints were changed in version 0.3, what has been changed and their eventually new position in the enterprise architecture maturity model for hospitals.

Table 58: The checkpoints that have been changed after the second focus group session

#	Focus Area	Level	Checkpoint	Change
4	1	A	Best-practices are used as inspiration when making new architectural products	Phrasing and position
9	1	B	When developing architectural products, best-practices are used as a basis and deviations are substantiated	Position
113	14	A	The architects are familiar with relevant best-practices in healthcare (e.g. the ZiRA)	Phrasing and position
117	14	B	For every architectural product, a deliberate choice has been made to link it to a best-practice or not.	Phrasing and position
120	14	C	All relevant best-practices are embedded in the architectural products of the hospital	Position
142	18	A	Agreements on interoperability are made incidentally with involved organisations.	Phrasing
144	18	B	Interoperability agreements have been made with involved healthcare organisations on process and information level. These agreements rest on standards (i.e. HL7)	Content
145	18	B	The architects from involved healthcare organisations effectively communicate with each other regarding relevant developments in the architectural area	Position

146	18	C	Interoperability agreements have been made with all stakeholders in the ecosystem on process and information level. These agreements rest on standards	Content
147	18	C	Clear agreements are made on which kind of processes and information is exchanged with stakeholders in the ecosystem	Content and position
148	18	C	The hospital is able to participate in agreement systems for the healthcare domain (e.g. MedMij)	Phrasing and position
149	18	D	The architecture allows that healthcare information can be stored and exchanged based on standards	Phrasing
150	18	D	The architecture allows cross-sector integration on all levels (process, application, information, and infrastructure) throughout the whole ecosystem	Content
151	18	D	The architecture of the hospital is interoperable by design	Phrasing

The discussion about the checkpoints was not part of the scope nor protocol of the second focus group session. However, it was deemed a useful addition to the session since it helped to make the checkpoints more robust. The participants raise the suggestion to validate these changed checkpoints once more. Since we did not establish the new phrasing and content together. This suggestion is elaborated in the next chapter.

4.3 Validity

The validity of qualitative research can be comprised of threats to internal credibility and external credibility. Internal creditability can be defined as the truth value, applicability, consistency, neutrality, dependability, and/or credibility of interpretations and conclusions within the underlying setting or group. To the contrary, external credibility is concerned with the degree of generalisation of a study across different populations of persons, settings, context, and times (Onwuegbuzie & Leech, 2007). This subchapter elaborates on the validity threats addressed in the focus group sessions. Table 59 shows which validity threats may have comprised the research design/data collection, data analysis, data interpretation, or theoretical validity of the focus group sessions. Subsequently, we show which methods we have applied to increase the legitimation of the focus group sessions which in turn reduces the validity threats.

Table 59: Validity threats to the focus group sessions, adapted from Onwuegbuzie & Leech (2007)

Type	Threat	Elaboration	Status
Internal	Descriptive validity	Refers to the factual accuracy of documentation by the researcher.	Reduced. By leaving an audit trail.
Internal	Theoretical validity	The degree to which a theoretical explanation is developed from research findings and whether it is credible, trustworthy, and defensible.	Reduced. By leaving an audit trail.
Internal	Observational bias	Arises when the data collectors have obtained an insufficient sampling of behaviours or words from the participants.	Reduced. By checking for representativeness.
Internal	Confirmation bias	The tendency for interpretations and conclusions based on new data to be overly congruent with a priori hypotheses.	Reduced. By leaving an audit trail and providing referential adequacy.
External	Investigation validity	This is the quality of craftsmanship of the researcher's quality control, not only a matter of methods used but also the researcher's personality traits.	Reduced. The facilitator was granted with a certificate of good conduct.
External	Interpretive validity	Refers to the extent to which the interpretation of the researcher is a representative understanding of the group's perspective.	Reduced. By member checking.
External	Population/ Ecological/ Temporal generalisability	A common error that is made at the interpretation stage is the tendency to generalise findings rather than utilising the data to obtain insights into particular processes and practices within a specific location and time.	Taken into account. The findings of the focus group sessions will not be generalised but only used as insights in the development of the enterprise architecture maturity model for hospitals.

Internal/ External	Researcher bias	Occurs when the researcher has personal biases or a priori assumptions that he/she is unable to bracket.	Partly reduced. Although it is not able to entirely reduce this bias, we have checked for researcher effects and clarified researcher bias.
Internal/ External	Reactivity	Involves changes in person's responses that result from being cognisant of the fact that one is participating in research.	Suffered. The participants were aware that they were participating in research.

Based on established studies on validity, Onwuegbuzie & Leech (2007) compiled a list of 24 strategies for assessing or increasing legitimation. From these strategies, we have applied five for reducing validity threats and increasing the legitimation of the focus group sessions. These are underlined in the last column in Table 59 and elaborated below.

Leaving an audit trail
This involves the researcher maintaining extensive documentation of records and data stemming from the study. The extensive documentation we maintained about the focus group sessions are the following: 1) raw audio files, 2) coded transcripts in NVivo, 3) focus group protocols for reconstruction purposes, and 4) photographs of the focus group sessions.

Checking for representativeness
Inaccurate generalisations prevail when 1) non-representative informants are sampled, 2) non-representative events or activities are used, and 3) inferences are made from non-representative processes (Miles & Huberman, 1994). The representativeness can be improved by increasing the number of participants, we have chosen to have seven participants, which is at the high-end of the optimum number of participants as described by Morgan (1996). Stratifying the sample also increases the representativeness, we obtained a stratified sample by obtaining participants with different professional backgrounds and including non-typical participants.

Referential adequacy
This is closely connected to leaving an audit trail. Referential adequacy is about raw supportive materials which provide a form of standard against which later data analyses, interpretations, and conclusions can be assessed for adequacy (Onwuegbuzie & Leech, 2007). These are not limited to electronically-recorded data, from the focus group sessions we have raw audio files and photographs.

Member checking
Member checking involves systematically obtaining feedback about the researcher's interpretations, and conclusions from the study group. According to Maxwell (2013), member checking is the most effective way of avoiding misinterpretation and misrepresentation of the "voice". After every discussion, the facilitator concluded what was said and what was decided and asked whether this was correct. This provided a feedback loop where consensus was reached and thus increasing the legitimation.

Checking for researcher effects/clarifying researcher bias
There are two sources of researcher bias: 1) the effects of the participants on the researcher and 2) the effects of the researcher on the participants (Miles & Huberman, 1994). These biases can be reduced with several exercises. We completed the following exercises to reduce this bias: 1) making the researcher's intentions clear, 2) conducting the focus group sessions in a neutral site, 3) avoiding elite bias by selecting a heterogeneous sample, 4) including non-typical participants, 5) utilising participants to provide background and historical information, and 6) continually keeping research questions firmly in mind (Miles & Huberman, 1994).

4.4 Conclusion

In this chapter we describe the approach, execution, results, and validity of the two focus group sessions. The goal of these focus group sessions was to validate the design of the enterprise architecture maturity model for hospitals. The sub-goal of the first focus group session was to validate the content, or the semantics of the enterprise architecture maturity model for hospitals. Whereas the sub-goal of the second focus group session was to validate the syntax of the enterprise architecture maturity model for hospitals.

Both the focus group sessions did not completely follow the intended protocol. During the first focus group session, it became clear that there was not enough time to handle everything as extensive as planned in the protocol. The facilitator noticed this on time and made some last-minute changes to the protocol. Because of these changes in protocol, everything was still handled in this session. However, the checkpoints and suggestions for improvement less extensive than the focus areas and capabilities.

The protocol of the second focus group session was planned a bit more generous, to prevent what had happened at the first focus group session. Now, however, an extra discussion erupted during this session. The discussion involved the checkpoints of the enterprise architecture maturity model for hospitals. An explanation for this could be because of the less extensive validation of these checkpoints during the first focus group session.

In the end, a new version of the enterprise architecture maturity model for hospitals derived. Table 60 summarises the changes made per new version. Version 0.2 was established after the first focus group session, whereas version 0.3 is a result of the second focus group session.

Table 60: Change log of the enterprise architecture maturity model by the focus group sessions

Version	Type of change	Subjects of change
0.2	Change in content or phrasing	For focus area 18: • 3 capabilities • 6 checkpoints • 1 suggestion for improvement For focus area 19: • The focus area itself • 3 capabilities • 5 checkpoints • 3 suggestions for improvement
0.2	New	For focus area 18: • 2 checkpoints
0.2	Position	None
0.2	Removed	For focus area 18: • 2 checkpoints • 2 suggestions for improvement
0.3	Change in content or phrasing	For focus area 18: • 8 checkpoints For focus area 19: • 3 checkpoints
0.3	New	None
0.3	Position	For focus area 18: • 2 capabilities • 3 checkpoints For focus area 19: • 5 checkpoints
0.2	Removed	For focus area 19: • The focus area itself

Several validity threats have been identified and methods have been applied to reduce these threats. One major threat however remains, that is the lack of validation on the changes made to the checkpoints after the second focus group session. We therefore decided to organise another validation for these changes, which is elaborated in the next chapter.

5. Extra validation on the design

This chapter describes extra validation on the design. This validation was not planned in the original research design. However, after the second focus group session, it became clear that the new changes made to the checkpoints still need validation. We decided to perform an expert interview with one of the authors of the original DyAMM, this to make sure that the last changes are correct according to the vision of the model. The content is not validated anymore with architects from healthcare, this since the changes are not that significant contentwise. Another reason to not consolidate these architects at this point is the fact that they will be able to give feedback during the case study validation as well.

Another point of discussion encountered during the focus group sessions. It became clear that there are some ambiguous interpretations of the newly added checkpoints. Especially about whether the checkpoint is interpreted as a totally technical checkpoint, concerning merely the content of the architectural products, or as a checkpoint which encompasses more than just that. To have a level of certainty that people will interpret the checkpoints correctly, think aloud sessions were initiated.

Figure 24 shows the process of extra validation. The first subchapter elaborates on the expert interview whereas the second subchapter elaborates on the think aloud sessions. Finally, the conclusions are drawn in the last subchapter.

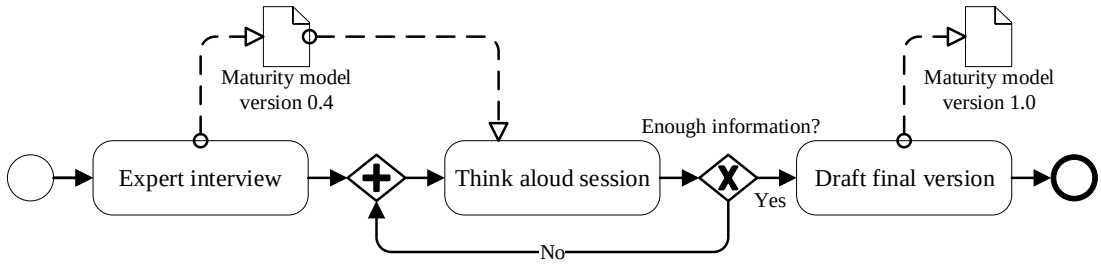

Figure 24: Process for the extra validation

5.1 Expert interview

The goal of the expert interview was to validate the latest changes made to the design of the model. In particular fourteen checkpoints. Eight checkpoints from focus area 18 where some content and phrasing has been changed after the last validation and five checkpoints which existed in focus area 19 and are now moved to existing focus areas. The protocol was straightforward, we handled each checkpoint individually, asking for every checkpoint whether the expert agrees with the position, and the content.

On 4 April, the interview took place. The expert in question is the main author of the original DyAMM. She has 25 years of experience in working with enterprise architecture of which 17 with working with the DyAMM. Table 61 shows the results of this validation. Whenever the expert disagreed with a change, the main researcher and the expert resolved this issue and came to a consensus about the particular checkpoint.

Table 61: Results of expert interview validation

#	Checkpoint	Validation verdict
4	Best-practices are used as inspiration when making new architectural products	Change
9	When developing architectural products, best-practices are used as a basis and deviations are substantiated	Delete
113	The architects are familiar with relevant best-practices in healthcare (e.g. the ZiRA)	Accept
117	For every architectural product, a deliberate choice has been made to link it to a best-practice or not.	Accept
120	All relevant best-practices are embedded in the architectural products of the hospital	Move and change
142	Agreements on interoperability are made incidentally with involved organisations.	Accept

144	Interoperability agreements have been made with involved healthcare organisations on process and information level. These agreements rest on standards (i.e. HL7)	Change
145	The architects from involved healthcare organisations effectively communicate with each other regarding relevant developments in the architectural area	Accept
146	Interoperability agreements have been made with all stakeholders in the ecosystem on process and information level. These agreements rest on standards	Accept
147	Clear agreements are made on which kind of processes and information is exchanged with stakeholders in the ecosystem	Accept
148	The hospital is able to participate in agreement systems for the healthcare domain (e.g. MedMij)	Accept
149	The architecture allows that healthcare information can be stored and exchanged based on standards	Accept
150	The architecture allows cross-sector integration on all levels (process, application, information, and infrastructure) throughout the whole ecosystem	Accept
151	The architecture of the hospital is interoperable by design	Accept

From the fourteen checkpoints, ten were immediately accepted. We decided that checkpoint 4 could now say reference architectures instead of best practices, this is a small change in the content. After a short discussion on checkpoint 9, we came to the conclusion that this checkpoint had become redundant and should, therefore, be deleted. We decided that checkpoint 120 would better fit in focus area 11 instead of focus area 14. For this movement, the checkpoint needed a different phrasing. To make sure that checkpoint 144 and 146 do not look almost exactly the same, we decided to change the phrasing of checkpoint 144.

The changes from this expert interview resulted in a new version (0.4) of the enterprise architecture maturity model for hospitals. Table 62 shows the changed checkpoints which resulted in version 0.4.

Table 62: The changed checkpoints which make up version 0.4

#	Checkpoint	Change
4	Reference architectures are used as inspiration when making new architectural products	Content
94	There is a policy in place about embedding reference architectures in the architectural products of the hospital	Position and phrasing
143	With some involved healthcare organisations interoperability agreements have been made on process and information level. These agreements rest on standards (i.e. HL7)	Phrasing

During the expert interview, the expert mentioned that some of the checkpoints could still be interpreted too technical. We decided to perform several think aloud sessions to get an idea of how people would interpret the new checkpoints. Next subchapter elaborates on this.

5.2 Think aloud sessions

Van Someren, Barnard, & Sandberg (1994, p.26) summarise thinking aloud as follows: “the subject is asked to talk aloud while solving a problem and this request is repeated if necessary during the problem-solving process thus encouraging the subject to tell what he or she is thinking”. The power of this method is that all the cognitive processes are captured when the subject thinks aloud. There are no interruptions, suggestive prompt or questions from the experimenter, making it a very direct non-biased data gathering on the cognitive processes of the subject (van Someren et al., 1994).

We use this method to find out how subjects assess the new checkpoints of the enterprise architecture maturity model for hospitals. When they think aloud, we will be able to capture their cognitive processes and draw conclusions on how they interpret and assess the checkpoints. The goal of these sessions is, therefore, to assess whether the subjects of the thinking aloud sessions do not interpret the new checkpoints too technically. Too technically in a sense that they only assess the architectural products, the content, to assess the checkpoints.

For the protocol of the thinking aloud sessions, we closely follow the practical procedures as prescribed by van Someren et al. (1994). The practical procedures consist of 1) the setting, 2) instructions, 3) warming up, 4) behaviour of the experimenter and prompting, 5) recording, 6) transcription of the protocol, and 7) review. The subjects were recruited at Sogeti, the consultancy company where the main

researcher is doing an internship. In total, three think aloud sessions were conducted. Two of the subjects have experience with architecture, whereas one of the subjects has not. The inclusion of this atypical subject provides a perspective of how someone without experience with architecture would assess these checkpoints. Table 63 shows demographic information about the subjects

Table 63: Demographic info of the subjects of the think aloud sessions

Subject	Function	Years of experience with architecture
1	Business architect	20
2	Business information manager	0
3	Management consultant	17

Firstly, we made sure that there was a comfortable setting for the subjects to make them feel at ease. The sessions all took place at the headquarters of the company they work for, making it a comfortable setting for them. We tried to find places as quiet as possible for the think aloud sessions. This was difficult since it was busy at the office that day, this resulted in some background noise which might have interrupted the subjects.

Secondly, clear instructions were given to the subjects. Van Someren et al. (1994) explains that is it important to not make the instruction too long since the more you say, the more subject will make up their own interpretations about what it is you want from them. Therefore, the instructions were as follows: 1) take an organisation in your mind of which you are going to assess the enterprise architecture maturity, and 2) talk out loud what you are thinking and how you assess whether the organisations fulfils the checkpoint or not.

Thirdly, the warming up was provided. It is important to give the subject an opportunity to practice thinking aloud. In general, it is wise to look for a task which is not too different from the target task (van Someren et al., 1994). Therefore, for our warming up, we provided five original checkpoints from the DyAMM for which the subject had to assess whether their imaginary organisations fulfil them or not.

Fourthly, it is important how the experimenter behaves and prompts. The experimenter did not interfere during the think aloud session, only when the subject stops talking. After the warming up phase, the experimenter also explained that he does not interfere and gave some feedback on how the subjects were doing.

Fifthly, the session was recorded on an audio file. As van Someren et al. (1994) suggests, we included the instruction and warming up phase in the recording.

Sixthly, the transcription is very important. It is important to type the audio recording out as verbatim as possible (van Someren et al., 1994). Therefore, everything was transcribed, including the thinking out loud of the subject and instructions, interruptions, and prompts by the experimenter, utterances by the subject or experimenter, and any background noise that was just as loud as the talking of the subject. The transcriptions hold all this information, including the identification of the speaker.

Seventhly, we reviewed the protocol with the subject. This provided very useful information, for example: after the first think aloud session, it became clear that the subject had a different organisation than a hospital in mind when assessing the maturity. He, therefore, had problems with generalising the checkpoints which had the word ‘hospital’ in it instead of ‘organisation’. We decided to replace the word ‘hospital’ with ‘organisation’ for the remaining two think aloud sessions.

5.2.1 Analysing the transcripts

The analysis of the transcripts is very important to be able to draw conclusions. We decided to not translate the Dutch transcripts to English since this will inherently result in wrong interpretations of the thinking of the subject when translating. Instead, we coded the Dutch transcripts. It is important to make a coding scheme for the coding of the transcripts (van Someren et al., 1994). In this scheme, you define the grain size and aggregation of cognitive processes of the subject. The coding scheme we used for coding the transcripts is presented in Table 64.

Table 64: Coding scheme for the think aloud transcripts

Code	Description
A	Concluding on the checkpoint
B	Making a consideration
C	Guessing
D	Prompt by the experimenter
E	Interruption by the experimenter
F	Introduction
G	Non-task related disturbances
H	Review
I	Warming up

The coding itself was completed in NVivo. Figure 25 shows a screenshot of the node tree as a result of the coding of the transcripts.

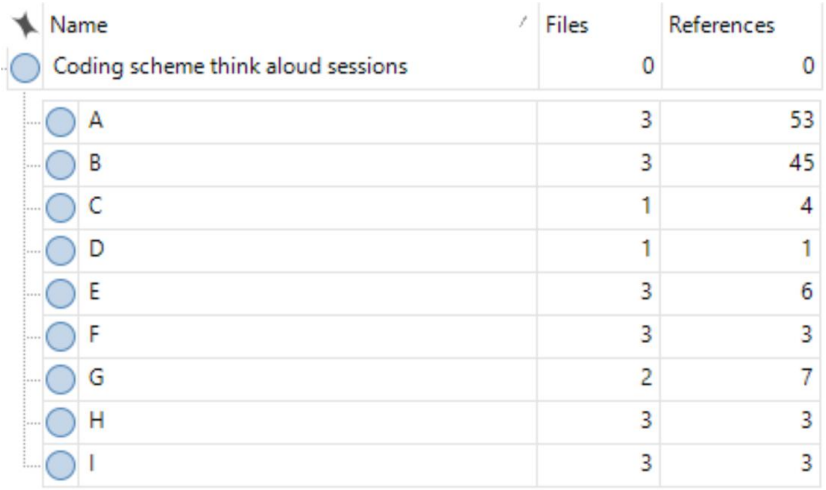

Figure 25: Screenshot of the coding in NVivo of the transcripts of the think aloud sessions

Table 65 shows the results of the coding per think aloud session. In the first session, almost every conclusion drawn on a checkpoint had a consideration attached to the conclusion. There were quite some disturbances in this first session, a total number of 5. The second session, with the subject with no experience in architecture, shows that this subject made more considerations than conclusions. He also guessed some of the conclusions. In the last session, it was clear that the subject was not very good at thinking aloud. He concluded much without talking about his consideration. After a prompt by the experimenter, he did talk more out loud though.

Table 65: Result of the coding per think aloud session

Code	Nr. of codes in 1	Nr. of codes in 2	Nr. of codes in 3
A	17	19	17
B	15	22	8
C	0	4	0
D	0	0	1
E	2	3	1
F	1	1	1
G	5	2	0
H	1	1	1
I	1	1	1

5.2.2 Results

The considerations by the subjects of the think aloud sessions show that they make the correct considerations. Meaning that they interpret the checkpoints the way we intend them. The transcripts also show that sometimes the subject does not know the answer to the checkpoint, in that case, the conclusion is skipped by the subject. In reality, this would mean that the checkpoint would not be achieved then.

There was one checkpoint where two subjects mentioned that they thought the checkpoint was vague. Therefore, the checkpoint was altered to make it clearer. This concerns checkpoint 148 'The hospital is able to participate in agreement systems for the healthcare domain (e.g. MedMij)'. We decided to make it clearer that the architecture of the hospital should be able to facilitate this. The result is: 'The architecture is set up in such a way that the hospital is able to participate in agreement systems for the healthcare domain (e.g. MedMij)'

5.3 Conclusion

In this chapter we describe two extra validations on the design of the enterprise architecture maturity model for hospitals. Firstly, an expert interview sharpened the new checkpoints in the model. The result is the deletion of one checkpoint, and changing the phrasing and/or content of 3 checkpoints, of which one was moved to another focus area as well. This resulted in version 0.4 of the enterprise architecture maturity model for hospitals.

Secondly, think aloud sessions were conducted to find out how people using the enterprise architecture maturity model for hospitals would interpret the new checkpoints. It became clear that they interpreted the checkpoint the way we intend them. One of the checkpoints, however, was still a bit vague. We made this checkpoint more clearer. The changing of this checkpoint results in version 1.0 of the enterprise architecture maturity model for hospitals. This is the final design which we will validate in case studies.

The final design of the model consists of 18 focus areas, 55 capabilities, 150 checkpoints, and 89 suggestions for improvement. Figure 26 shows the matrix. The full description of all the checkpoints and suggestions for improvement are displayed respectively in Appendix D and Appendix E. In total, 4 versions of the model derived during the process of validating the design. How, where, and when these versions derived during the process is visually presented in the BPMN process in Figure 27.

#	**Focus Area**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	Development of architecture		A			B			C					
2	Use of architecture			A			B				C			
3	Alignment with business strategy		A			B					C			
4	Alignment with realisation			A				B			C			
5	Relationship to the As-Is state					A				B				
6	Responsibilities and authorities				A		B					C		
7	Alignment with change portfolio				A				B		C			
8	Monitoring				A		B		C					
9	Quality assurance								A		B		C	
10	Management of the architectural process							A		B		C		
11	Management of the architectural products					A			B					C
12	Commitment and motivation		A					B		C				
13	Implementation of the architectural role				A		B		C				D	
14	Architectural method				A					B			C	
15	Interaction and collaboration			A		B				C				
16	Architectural tools							A				B		C
17	Budget and planning					A						B		C
18	Interoperability			A				B			C		D	

Figure 26: Version 1.0 of the enterprise architecture maturity matrix for hospitals

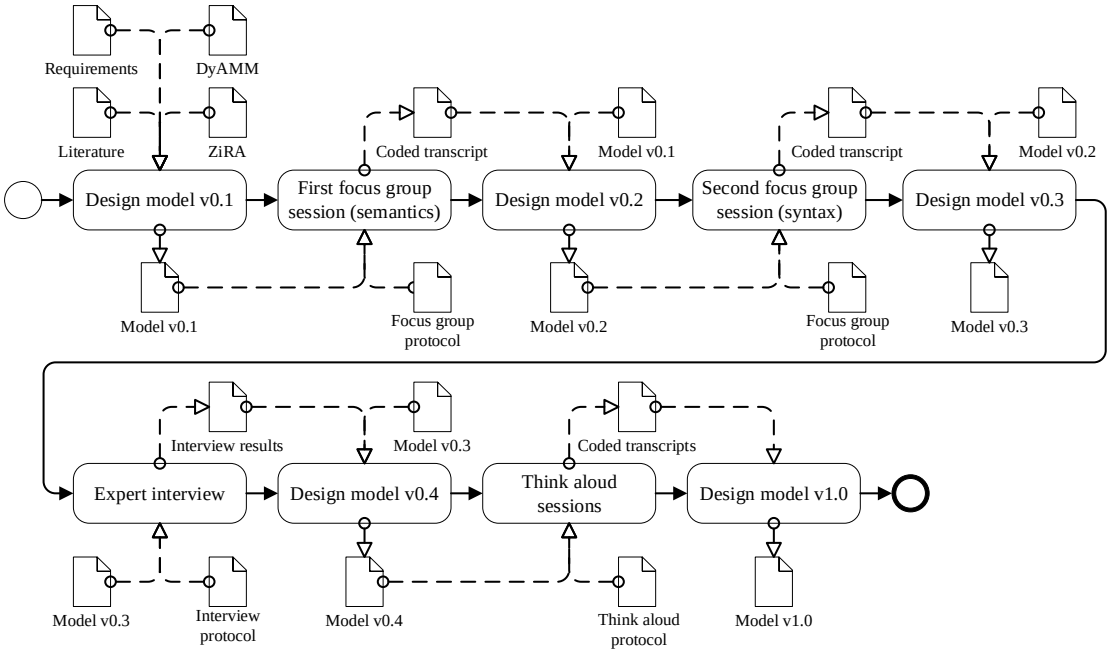

Figure 27: The process of validating the design of the artefact in BPMN

6. Case studies

This chapter describes the ex post naturalistic evaluation of the enterprise architecture maturity model for hospitals. The design of the model is extensively validated through focus group sessions, an expert interview, and thinking aloud sessions. Following the research design described in chapter 1.2, the model itself is validated in Dutch hospitals. In total, seven case studies are completed in our multiple case study research. The first subchapter elaborates on the approach of the case study validation, in specific the design and the protocol. The second subchapter describes the execution of the case studies, whereas the third subchapter encompasses the results of the case studies. The fourth subchapter discusses the validity of the case studies. Finally, the conclusions are drawn in the last subchapter.

6.1 Approach

Yin (2015) advises that whenever you have the choice, multiple-case designs may be preferred over single-case designs. The design of this case study research validation is a multiple-case holistic design with a replication logic. We press for six or more replications since this gives us a higher degree of certainty for support of our initial proposition (Yin, 2015). Figure 28 shows the multiple-case holistic design as adapted from Yin (2015).

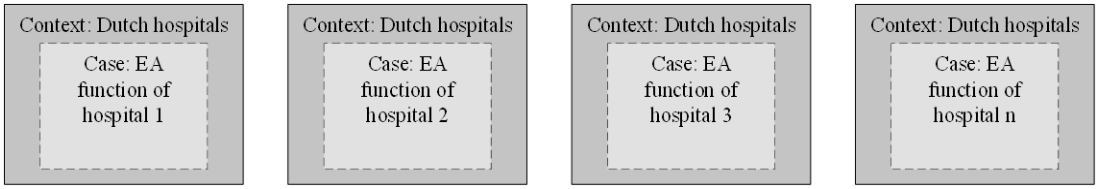

Figure 28: Multiple-case holistic case study design

In the design of a case study research design, five components are important: 1) a case study's question, 2) its proposition, 3) its unit(s) of analysis, 4) the logic linking the data to the propositions, and 5) the criteria for interpreting the findings (Yin, 2015). Table 66 elaborates these five components for our case study research design.

Table 66: Case study research design

Component	Description
Question	The case study's question is sub-question RQ4: How does the enterprise architecture maturity model perform in one or more hospital(s)?
Proposition	The proposition of this case study follows the goal of the model closely. Translating the goal into the proposition: the model is able to evaluate and give suggestions to improve the enterprise architecture maturity of hospitals.
Units of analysis	The units of analysis are the enterprise architecture functions of Dutch hospitals.
Linking the data to the proposition	Here, we look in two-fold whether the model performed well. 1. Firstly, we report the maturity profile back to the participants and let the architects fill in a survey to assess their: 1) perceived usefulness, 2) perceived ease of use, and 3) intention to use. This survey is based on the Technology Acceptance Model (TAM) by Venkatesh & Davis (2000). 2. Secondly, we perform an expert interview to 1) gain perceptions on the extra focus area, 2) gain insight in whether the hospital's architects can relate to the eventual profile of the hospital's enterprise architecture function, 3) gain insight in whether they think the working method is feasible, and 4) gain insight in whether the participants think that the suggestions for improvement coming from the maturity profile make sense for their hospital.
Criteria for interpretation	The criteria for interpreting the findings is six-fold: 1. We look whether we were able to fully use the model, i.e. use all the aspects (focus areas, capabilities, and checkpoints). 2. Interpret the results from the TAM survey to assess the perceived usefulness, perceived ease of use, and intention to use of the participants.

3. Code the expert interviews to assess whether they think that the extra focus area is feasible.
4. Code the expert interviews to assess whether they think that the maturity profile fits their hospital's enterprise architecture.
5. Code the expert interviews to assess whether they think the working method is feasible.
6. Code the expert interviews to assess whether they think that the suggestions for improvement make sense for their hospital.

To interpret the results from the survey based on the Technology Acceptance Model (TAM), we capture the goal, questions, and metrics in a GQM model (van Solingen & Berghout, 1999). The goal follows the question of the case study research approach, whereas the questions are based on the different variables from the TAM. Figure 29 shows the GQM model to interpret the results from the survey based on the TAM.

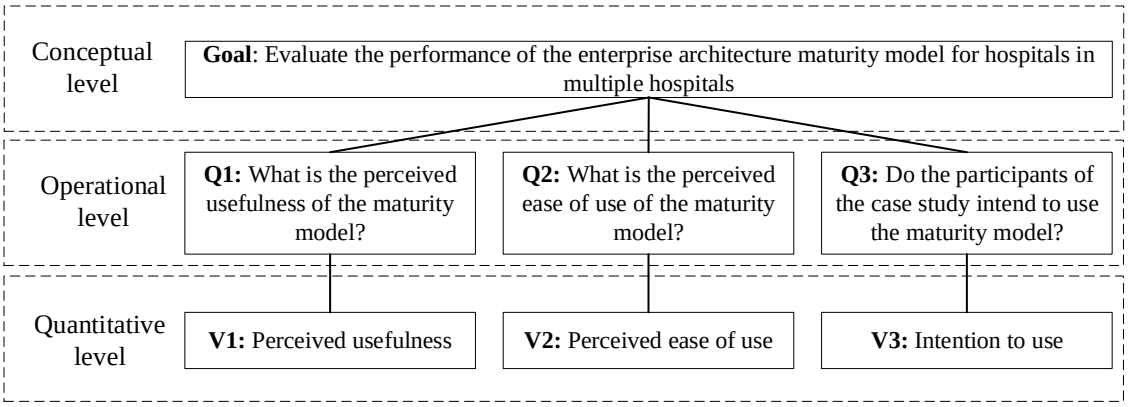

Figure 29: GQM model TAM

The survey is based on the statements from Venkatesh & Davis (2000). In total, the survey consists of ten statements with a 7-point Likert scale. Four statements for perceived usefulness, four statements for perceived ease of use, and two statements for intention to use.

What is out of scope for this case study design, is to validate whether the model is actually able to improve the maturity level of the enterprise architecture of hospitals. For this, a longitudinal study is necessary to confirm that by focussing on the improvement suggestions a higher maturity level is achieved.

6.1.1 Protocol

To establish the preferences of architects from hospitals in how they would like to use the enterprise architecture maturity model, we performed a survey. 44 IT professionals responded to the survey, performed on 6 March 2019.

Table 67 describes their demographic info while Table 68 presents descriptive statistics on the years of experience they have in healthcare. One of the multiple-choice questions in this survey is about how they would like to utilise the enterprise architecture maturity model for hospitals. Beforehand, the model was presented and explained to the respondents. The question was:

How would you like to utilise the model? (Caution: there is a balance between how much time you spent within these methods and how accurate the results are)

The multiple-choice answers are based on the different implementations of the DyAMM known so far and are as follows:

Answers:	Votes:
1. Short questionnaire (least time, least accurate)	7
2. Extensive questionnaire (less time, less accurate)	31
3. A questionnaire with independent expert analysis (more time, more accurate)	5
4. Extensive analysis by independent experts (most time, most accurate)	1

Table 67: Demographic info respondents from the survey

Function	**Number**
Information architect	12
IT architect	5
Information manager	5
Clinical computer scientist	5
Project manager	4
Advisor	3
Enterprise architect	3
Program manager	3
Other	4
Years of experience in healthcare	**Number**
1-5	11
6-10	10
11-15	6
16-20	7
21-25	5
26-30	5

Table 68: Descriptive statistics of years of experience in healthcare of the respondents from the survey

Descriptive	**Number**
Count	44
Min	1
Max	30
Mean	13.70
Median	11
Standard deviation	9.14

Since the majority of the professionals gave their preference on utilising the model through an extensive questionnaire, we process this working method in our case study protocol. Utilising the enterprise architecture maturity model for hospitals through an extensive questionnaire is also in line with the non-functional requirements we established in chapter 3.1.1. Table 69 shows the non-functional requirements which are originally presented in Table 13.

Table 69: Copy of the non-functional requirements from Table 13

#	**Requirement**	**Source**	**Type**
6	The model should have a holistic approach	Interview 3, (Carvalho et al., 2016; Meyer et al., 2011)	Non-functional
8	It should be possible to perform a benchmark with other hospitals with the model	Interviews 2 & 3	Non-functional
9	The model should be easy to use	Interviews 2 & 3	Non-functional
10	Using the model should not take too much time, and give results fast	Interview 2	Non-functional

The procedure we follow for conducting a multiple-case study research is presented in Figure 30 and inspired by Yin (2015). The case study protocol itself is displayed in BPMN in Figure 31 and elaborated below.

1. Let architects and other professionals who are involved in the architecture function of the hospital fill in an extensive questionnaire with all the checkpoints of the enterprise architecture maturity model for hospitals. They must individually assess with a yes or a no whether they achieved a checkpoint.
2. Make a report for every architect or other professional with a maturity profile and suggestions for improvement based on their interpretation and answering of the checkpoints.

3. In a meeting, give the architects their report with its suggestions for improvement and let them review it and fill in the TAM survey.
    a. The reason to do this in a meeting is to make sure that the architects do not share their maturity profiles with each other beforehand and influence each other's perceptions. Also, when doing this in a meeting, the facilitator is also able to directly observe the participants while they review the profile and fill in the TAM survey.
    b. If more employees used the model and should receive a profile but are not present at this meeting, we ask the participants of this meeting to not communicate about the profile towards these employees. The profile with the TAM survey will then be sent to these employees with the question to review it and fill in the survey.
4. In this same meeting, come to <u>one</u> enterprise architecture maturity profile for the hospital. The assessment of the checkpoints from the different employees will have inconsistencies. These inconsistencies derive from different interpretations of the somewhat ambiguous checkpoints. Also, different perspectives from a heterogeneous group will results in inconsistencies in the results.
    a. For every inconsistency in the results from the involved employees, make sure that during this meeting a consensus is reached to whether the checkpoint is achieved or not.
        i. When there is not enough time to handle all inconsistencies, make a priority amongst the inconsistencies. The priority is based on whether a checkpoint is blocking (i.e. blocking the maturity profile to go to a higher scale), and whether there are large deviations in the answers (i.e. where there is a checkpoint only has one yes or no, this checkpoint has a lower priority than a checkpoint where there is a 50/50 distribution).
5. Make a report on that profile, along with the suggestions for improvement.
6. Conduct an expert (group) interview to gain perceived feasibility and insights about 1) the extra focus area, 2) the enterprise architecture maturity profile, 3) the working method, and 4) the suggestions for improvement.
7. Synthesise results.

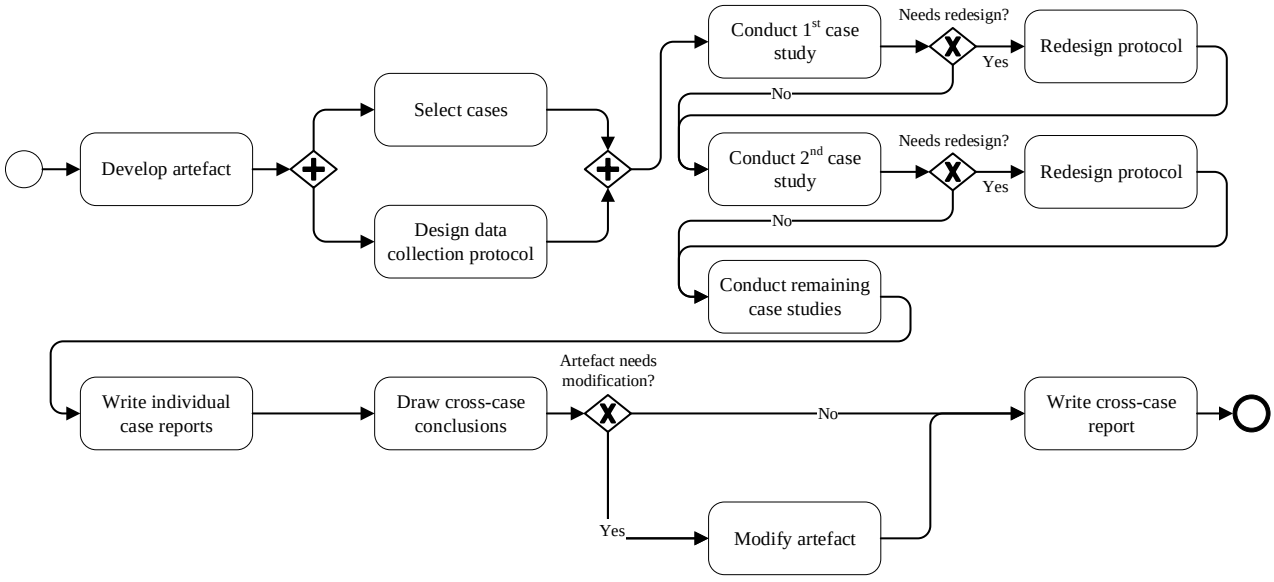

Figure 30: BPMN of the multiple-case study protocol, adapted from Yin (2015)

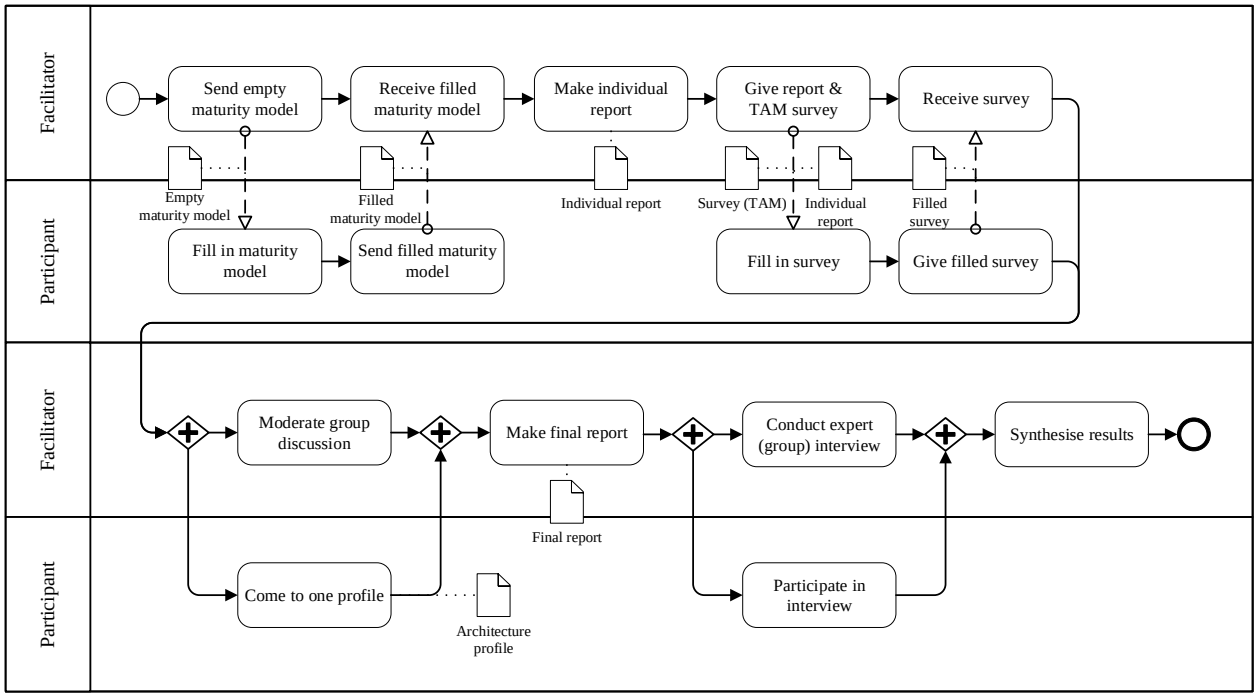

Figure 31: BPMN of the case study protocol

6.2 Execution

In total, we conducted seven case studies. Among the seven hospitals that participated in the case studies, a total of 34 IT professionals used the enterprise architecture maturity model for hospitals, i.e. the first part of the protocol as described in Figure 31. Table 70 shows demographic info about the hospitals and Table 71 about the IT professionals who were involved. To ensure privacy for the involved hospitals, the demographic info is grouped in such a way that one cannot trace back which hospital it concerns. One case study was conducted in April 2019. The others in May and June 2019.

Table 70: Demographic info of the hospitals

Hospital	Number of beds	Number of employees	Type
A	500-700	4000-6000	Normal
B	700-900	4000-6000	Normal
C	500-700	10,000+	Academic
D	700-900	4000-6000	Normal
E	900-1100	10,000+	Academic
F	700-900	6000-10,000	Academic
G	1100+	10,000+	Academic

Table 71: Information about the participants of the case studies

Participant	Hospital	Function	Years of experience in healthcare IT	Filled in TAM survey?	Present at group discussion?	Present at expert interview?
1	A	Information architect	12	No	-	-
2	B	IT advisor	4	Yes	Yes	No
3	B	IT advisor	9	No	No	No
4	B	Information security officer	2	Yes	Yes	No
5	B	IT advisor	2	Yes	Yes	No

6	B	Project manager	23	No	No	No
7	B	IT architect	10	Yes	Yes	Yes
8	C	Data architect	18	Yes	Yes	Yes
9	C	Architect	9	Yes	Yes	Yes
10	C	Enterprise architect	5	Yes	Yes	Yes
11	C	Architect	1	Yes	Yes	Yes
12	C	Information architect	20	Yes	Yes	No
13	D	Manager CIO office	1	Yes	Yes	-
14	D	Enterprise architect	19	Yes	Yes	-
15	D	Infrastructure architect	20	Yes	Yes	-
16	E	Medical computer scientist	7	Yes	No	No
17	E	Project manager	30	Yes	No	No
18	E	Advisor	5	Yes	No	No
19	E	Data architect	6	No	No	No
20	E	Enterprise architect	4	Yes	Yes	Yes
21	E	Information architect	30	Yes	Yes	Yes
22	E	Medical computer scientist	9	No	No	No
23	F	Information manager	17	Yes	No	Yes
24	F	Application architect	8	Yes	No	Yes
25	F	IT architect	30	Yes	Yes	Yes
26	F	IT manager	3	Yes	Yes	Yes
27	F	Architect	6	Yes	No	Yes
28	F	Solution architect	18	Yes	No	Yes
29	F	IT architect	19	Yes	No	Yes
30	G	Enterprise architect	30	Yes	-	-
31	G	Infrastructure architect	1	No	-	-
32	G	Business architect	8	Yes	-	-
33	G	Enterprise architect	16	No	-	-
34	G	Infrastructure architect	14	No	-	-

Each of the IT professionals that used the enterprise architecture maturity model for hospitals received an introduction on the model, an individual report, and the TAM survey. An example of an individual report (in Dutch) is given in Figure 32. 17 of the case study participants were present at the group discussion to come to one maturity profile for the hospital, these 17 received the report and filled in the survey in person while the main researcher supervised. The other 17 IT professionals received the report and TAM survey through email, of which ten of them responded to this survey. In total, 26 out of the 34 participants filled out the TAM survey, making a response rate of 76.5%.

At none of the hospitals we had sufficient time to discuss all inconsistencies in the second meeting, we only handled the checkpoints that were blocking and had large deviations, conform protocol. Almost all the case studies were conducted according to the protocol, except for the case studies at hospital A and hospital G. The empty list of checkpoints from the enterprise architecture maturity model for hospitals was sent to multiple employees of hospital A. However, only one, the only architect, filled the list of checkpoints. Therefore, there was no need to have a group discussion to come to one maturity profile. The individual report of that architect was also the final report for hospital A. We therefore cancelled the remainder of the case study.

The case study at hospital G did not follow the protocol as well. It was not possible to plan a further meeting after the participants received their individual report and the TAM survey. This probably explains the low response rate on the TAM survey of this hospital.

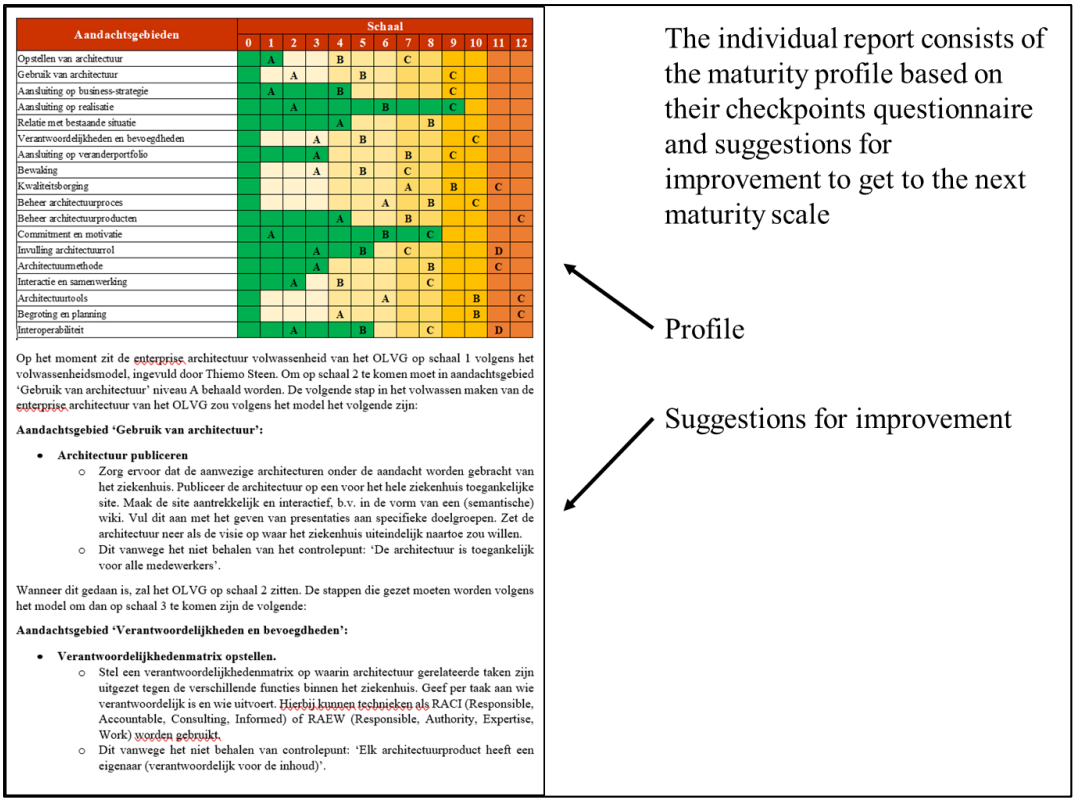

Figure 32: Example of an individual report (in Dutch)

6.3 Results

As mentioned before, 34 individual reports were created for the hospitals. These were based on the list of checkpoints that the IT professionals of the hospitals filled in. They assessed by themselves whether their hospital fulfilled the checkpoints or not. One of the criteria for interpretation of the results is to check whether we were able to use all aspects of the model. This is the first thing we will discuss in this subchapter. Following are the results of the TAM survey, and finally, we discuss the results from the expert (group) interviews.

From the 34 returned lists of checkpoints, 19 were completely filled out, whereas 15 were not. From these 15 incomplete lists, six left one checkpoint empty. A total of 189 out of the 5100 checkpoints were not filled, which is 3.7%. 143 of the 189 empty checkpoints originated from hospital B. In Table 72 we show which checkpoints were not filled and how many times this occurred. We only show the checkpoints that were left empty more than twice. The checkpoints in the table are the checkpoints corresponding to Appendix D.

Table 72: Checkpoints that were left empty more than twice by the participants

Checkpoint	Number of times left empty	Percentage
7	4	11.8%
38	5	14.7%
40	4	11.8%
44	3	8.8%
48	3	8.8%
50	3	8.8%
53	3	8.8%
64	4	11.8%
67	3	8.8%

69	3	8.8%
71	3	8.8%
82	4	11.8%
93	3	8.8%
94	3	8.8%
100	3	8.8%
107	3	8.8%
109	3	8.8%
110	3	8.8%
111	3	8.8%
117	3	8.8%
119	3	8.8%
133	4	11.8%
135	3	8.8%
147	4	11.8%
150	3	8.8%

We also want to emphasise on the extra checkpoints we added to the original DyAMM. Table 73 shows how many times these checkpoints were left empty. The last column shows how many per cent of the total checkpoints was left empty. From the fourteen extra checkpoints, 19 of the 476 were not filled. This makes a percentage of 4, which is slightly higher than the 3.7% of all checkpoints.

Table 73: The new checkpoints and how many times they were left empty by the participants

Checkpoint	Number of times left empty	Percentage
4	1	2.9%
94	3	8.8%
113	0	0%
117	3	8.8%
141	1	2.9%
142	0	0%
143	0	0%
144	1	2.9%
145	1	2.9%
146	0	0%
147	4	11.8%
148	0	0%
149	2	5.9%
150	3	8.8%

6.3.1 Technology Acceptance Model

This subchapter elaborates on the results from the Technology Acceptance Model (TAM) survey. In total, 26 experts who participated in the case studies filled in the survey. They filled in the TAM survey right after they received their individual report. This is to prevent that their perceptions are biased through the group discussion. Their demographic info is presented in Table 74. Descriptive statistics about the years of experience in healthcare IT is described in Table 75, while Figure 33 shows the distribution. Looking at the descriptive statistics and the distribution of the years of experience, we can conclude that this a diverse group concerning their experience. Their functions are less diverse, most of them are architects.

Table 74: Demographic info respondents TAM survey

Function	Number
Architect	16
Advisor	4
Manager	3
Clinical computer scientist	1
Project manager	1
Information security officer	1

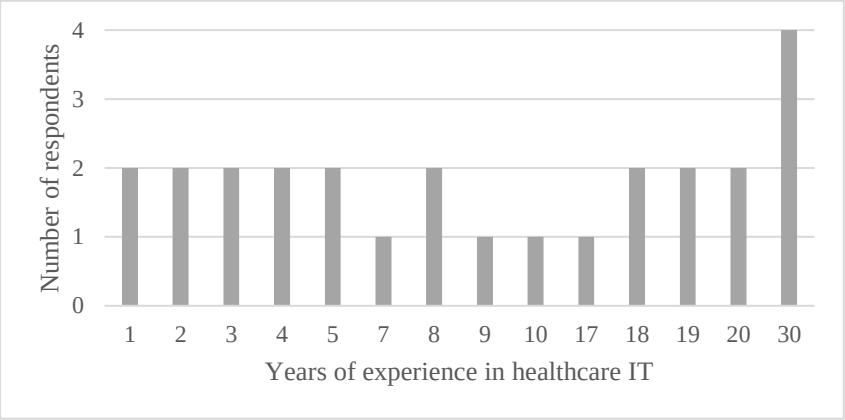

Figure 33: Distribution of years of experience of respondents TAM survey

Table 75: Descriptive statistics of the experience of the respondents of the TAM survey

Descriptive	Number
Count	26
Min	1
Max	30
Mean	12.4
Median	8.5
Standard deviation	10

The survey consisted of 10 statements, inspired by Venkatesh & Davis (2000). Table 76 shows the results of the TAM survey. Appendix F shows the SPSS output of the descriptive statistics. The first column shows which variable from the GQM model in Figure 29 the statement addresses. The statements are scored on a seven-point Likert scale, where 1 = strongly disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = moderately agree, and 7 = strongly agree.

Table 76: Results TAM survey - statements

Variable	Statement	Valid values	Min	Max	Mean	Standard deviation
V3	Assuming I have access to the maturity model for hospitals, I intend to use it.	26	3	7	5.69	0.9
V3	Given that I have access to the maturity model for hospitals, I predict that I would use it.	26	1	7	5.27	1.2
V1	Using the maturity model for hospitals improves my performance in my job.	26	2	7	4.81	1.1
V1	Using the maturity model for hospitals in my job increases my productivity.	26	2	6	4.12	1.1
V1	Using the maturity model for hospitals enhances my effectiveness in my job.	26	2	7	4.85	1.2

V1	I find the maturity model for hospitals to be useful in my job.	26	2	7	5.35	1.0
V2	My interaction with the maturity model for hospitals is clear and understandable.	26	1	7	5.00	1.4
V2	Interacting with the maturity model for hospitals does not require a lot of my mental effort.	26	2	7	4.77	1.6
V2	I find the maturity model for hospitals to be easy to use.	26	1	7	4.69	1.5
V2	I find it easy to get the maturity model for hospitals to do what I want it to do.	26	1	6	4.08	1.2

Before calculating the value of the three variables by merging the means of the statements that address the variable, we calculated the internal validity. Through calculating the Cronbach's alpha per variable, we were able to assess whether the internal validity is sufficient enough to merge the means of the statements per variable. Table 77 shows the internal validity in the form of the Cronbach's alpha of the three variables. In Appendix F we show the SPSS output for the Cronbach's alphas.

Table 77: Internal validity of the TAM variables

Variable	Number of statements	Cronbach's alpha
V1: Perceived usefulness	4	0.803
V2: Perceived ease of use	4	0.748
V3: Intention to use	2	0.807

Since we are comparing groups and this is not a clinical application, we conclude that the internal validity is satisfactory since all the scores are above 0.7 (Bland & Altman, 1997). We, therefore, calculated the average of the statements per variable per respondent. In Table 78 we show the descriptive statistics of the variables. The SPSS output of these descriptive statistics is presented in Appendix F.

Table 78: Descriptive statistics of the TAM variables

Variable	Valid values	Min	Max	Mean	Standard deviation
V1: Perceived usefulness	26	2	6.5	4.78	0.86
V2: Perceived ease of use	26	2	6.25	4.63	1.07
V3: Intention to use	26	3	7	5.48	0.97

The results show that all the variables, measured on a seven-point Likert scale, are positive. The perceived usefulness and perceived ease of use of the participants are slightly positive with a value of 4.78 and 4.63, respectively. The intention to use the enterprise architecture maturity model for hospitals is slightly higher with a value of 5.48.

6.3.2 Expert (group) interviews

Using the individual reports as a basis, we held group discussions at the hospitals to form one enterprise architecture maturity profile. During these group discussions, it became clear that the checkpoints are interpreted differently by the participants. This suggests that the checkpoints are ambiguous. Other than this observation, nothing relevant derived from these group discussions.

The final profiles of the hospitals are presented in Appendix G, except for hospital G, for which there is no final profile.

In this subchapter, we elaborate the expert (group) interviews that we performed. These concerned the final maturity profile and the corresponding suggestions for improvement for the hospital. These interviews were semi-structured and we asked the following questions:

1. What are your thoughts about the final profile and its suitability on the enterprise architecture function of your hospital?
2. What do you think of the suggestions for improvement?
3. What is your opinion about the working method?
4. What do you think of the extra focus area?

We performed these interviews with four of the seven hospitals. At hospital B, C, E, and F. The reason for this is that one of the hospitals did not reply on the invitation and its reminders while the other two replied that they no longer had time to participate in the case study. Firstly, we show who participated in these expert interviews and the coding of the interviews in NVivo. Secondly, we address the questions that we asked and accumulate the opinions of the different hospitals.

Participants and their interview coding

The expert interview at hospital B was performed with the IT architect, participant number 7 in Table 71. In Figure 34 we show the coding of the interview in NVivo.

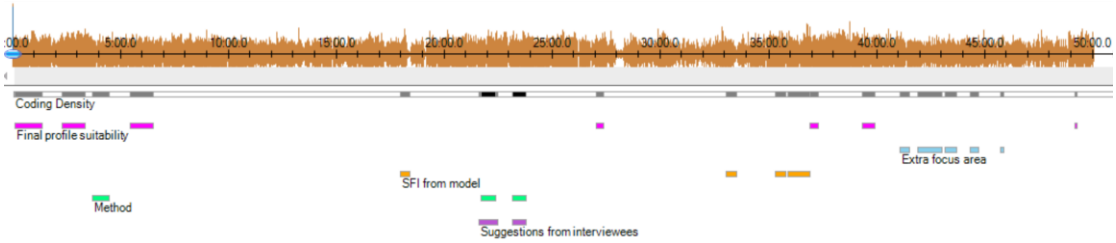

Figure 34: Coding of the expert interview of hospital B

At hospital C we held an expert group interview, the whole architecture team was present at this interview. These are the participants 8 through 12 in Table 71. Figure 35 shows the coding of that group interview in NVivo.

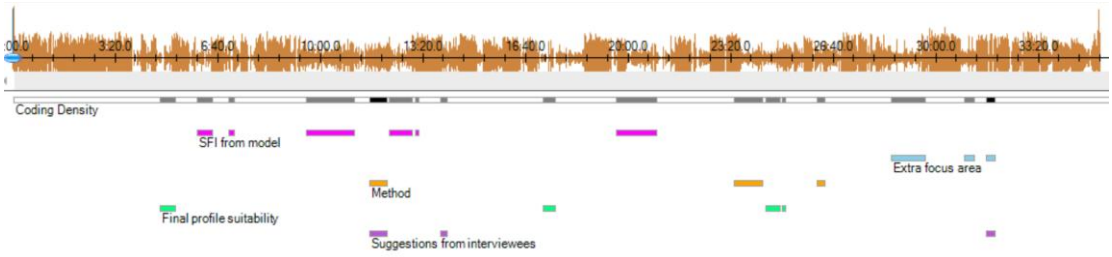

Figure 35: Coding of the expert group interview of hospital C

The same two architects at hospital E with whom we held the discussion to come to one profile were the attendees for the expert group interview. These are the participants 20 and 21 in Table 71. Figure 36 shows the coding of that group interview in NVivo.

Figure 36: Coding of the expert group interview of hospital E

At hospital F the whole architecture team was present at the expert group interview, participants 23 through 29 in Table 71. Figure 37 shows the coding of that expert group interview in NVivo.

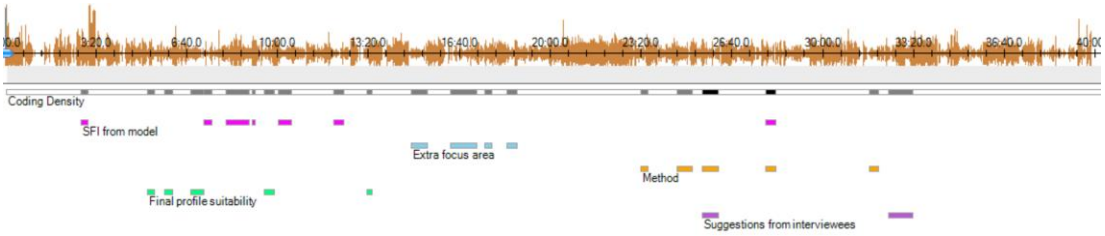

Figure 37: Coding of the expert group interview of hospital F

During the interviews, some suggestions from the interviewees derived as well. We coded them separately in NVivo. Figure 38 shows the node tree with the number of codes per node of the expert (group) interviews.

Name	Files	References
Expert (group) interviews	0	0
Extra focus area	4	14
Final profile suitability	4	19
Method	4	17
SFI from model	4	24
Suggestions from interviewees	4	8

Figure 38: Node tree in NVivo of the expert (group) interviews

Suitability of final profile

All the hospitals agree with their final maturity profile, they can relate it to their enterprise architecture function. Hospitals C and E are dissatisfied with the results, in a sense that they would have hoped they had a higher maturity profile, but they agree that they do not have that (yet). Someone at hospital F summarised with: “If I look at the focus areas on which we should place emphasis, then I think that these are focus areas that we indeed should focus on. And we recognise them as well”.

At hospital B some focus areas were identified as too high, we concluded that that was the consequence of only handling the blocking focus areas and their checkpoints in the first meeting.

Hospitals C and F mentioned that this profile will help them to set priority in becoming more mature and helps to make a roadmap. Someone at hospital C said: “It helps us define what to do next and define priorities”.

Suggestions for improvement from the final report

Three of the four hospitals were very satisfied with the suggestions for improvement from the final report. For example, at hospital E one of the two interviewees said: “This is something that I would really want to have (about the third suggestion for improvement)”. On which the other replied: “I totally agree with you; I would really want that as well. Whole-heartedly, yes”.

At hospital F one mentioned: “If you look at the final suggestion for improvements, then I think that these are the correct suggestions”. They especially liked that the suggestions give a tangible direction to achieve them.

The interviewee at hospital B had not really looked into the suggestions for improvement yet. But while we were discussing the report, it became clear that he liked the suggestions and found them valuable. In the end, he emphasised: “And then I indeed think the architecture would be a bit better if we did those things”.

The exception here is hospital C. The enterprise architect mentioned: “I can’t really do something with the suggestions for improvement in this report”. It became clear that he found them too detailed for the

analysis that has been done at the hospital. He also was not sure whether he even wanted to improve these aspects of the enterprise architecture function. There was some doubt on whether he even wanted to achieve the next level: “Why would I want to go to level 4? That’s something I’m not sure of”. Finally, there was some discussion amongst the other participants, which seem to disagree with the enterprise architecture on some points. They concluded that some suggestions for improvement made sense in their opinion, but only in a certain context.

Method

With this question, we tried to get the perceptions of the participants on the working method. Did they like the protocol? It became very clear that none of the participants liked to fill in the empty maturity model, i.e. the questionnaire with all the checkpoints. At hospital C they thought there were simply too many questions, and that a lot of them seemed to be copies of others. Hospital F also mentioned this, they thought that there was a lot of overlap in the questionnaire. They also disliked the fact that you must answer with a yes or no, they found it hard to decide when you say yes or no.

The interviewees at hospital E brought up that the questions were ambiguous. Hospitals C and F noticed that there were quite some differences in the interpretation of the questions, also suggesting that they are ambiguous. At hospital B the architect received feedback from the other participants that they found it difficult to fill in the questionnaire: “That’s the feedback I received, that they found it difficult to fill in the questionnaire”. This might explain why 143 of the 189 checkpoints that were left empty came from this hospital.

What all the hospital did like, was the first session, the group discussion, in which we resolved the inconsistencies in the answers. Hospital B liked that we focussed on the checkpoints where there were big differences in the answers. Hospital C, E, and F mentioned that they found it useful to see the different interpretations and opinions of everyone who filled in the questionnaire. At hospital E someone said: “In the previous session it became clear that there were different interpretations, so it is good to have such a meeting, to resolve these differences”. At hospitals E and F, we did not hold the group discussion with everyone who filled in the questionnaire. These hospitals mentioned this fact, and that they would have wanted this in retrospect. Both thought that having everyone involved in the group discussion would have more value.

All in all, they all concluded that they did like the protocol in the end. Especially by keeping the outcome of the assessment in mind. Someone at hospital E concluded this part of the interview with: “It was definitely worthwhile to do this assessment, even with the horrible questionnaire”.

Extra focus area

Since the biggest change that we made to the original model is the extra focus area, we wanted to emphasise this part in the expert (group) interview. All the hospitals support the outcome of the focus groups, saying that interoperability is important for hospitals. Some emphasis from someone at hospital B: “I think interoperability is super important”. And at hospital E they topped this by saying: “I think the element is definitely important. How the hospital interacts in the ecosystem is almost its right to exist”.

However, there were also some remarks on this subject. The architect at hospital B thinks the following: “It is essential at this point, but it might become standard in a couple of years, then the focus area might become less relevant”. At hospital E there was a discussion on the term interoperability, that it sounded like it has too much focus on the content of the architecture. There they concluded that it might be wise to change the name of the focus area. The final remark is from hospital C, where they concluded that it is important to also check the interoperability of other stakeholders in the ecosystem: “If you are the only one emphasising on interoperability in the ecosystem, then it would not make much sense to measure it”.

Suggestions from the interviewees

During the interviews, some suggestions to improve the model or the process arose. We aggregate them in this section. From hospital B we received the suggestion to rate the checkpoints, instead of only having a yes or no answer: “There is no nuance in the answers, it would be nice if you could rate them from 1 to 10 for example”.

Following their comment about interoperability, hospital C suggested that it would be nice if you could measure the level of interoperability throughout the entire ecosystem.

Hospitals E and F both suggest having the group discussion with everyone who has filled in the questionnaire. Hospital E adds that during that session, it would also be nice to determine the ambition and roadmap of the enterprise architecture function.

The final suggestion is from hospital F, which is to reduce the large number of checkpoints asked in the first step, they suggest to only assess the checkpoints of the first scales.

6.4 Validity

The validity threats to our case study research are construct, internal, external, and reliability threats (Yin, 2015). Construct validity concerns the failure to develop a sufficiently operational set of measures and that subjective judgments are used to collect the data. Internal validity involves the incorrect conclusion of a causal relationship. External validity deals with the generalisability beyond the immediate study. The goal of reliability is to minimise the errors and biases in a study. The objective is to be sure that, if a later researcher follows the same procedures as described by an earlier researcher and conducts the same case study over again, the later investigator should arrive at the same findings and conclusions (Yin, 2015). In Table 79 we show which tactics we performed to reduce these validity threats. How we applied these tactics is elaborated after the table.

Table 79: Tactics to reduce validity threats, deducted from Yin (2015)

Type of threat	Tactics that are performed to reduce the threat	Elaboration
Construct validity	Using multiple sources of evidence	Case study findings and conclusions are likely to be more convincing and accurate if they is based on several different sources of information. Typically, this is established by triangulating data, investigators, theories, and methods.
	Establishing a chain of evidence	The chain of evidence should make it possible for an external observer to trace the steps in either direction from the derivation of any evidence from initial research questions to ultimate case study questions.
Internal validity	Doing pattern matching	This is one of the most desirable techniques, where the findings of the case study are logically matched to a predicted pattern.
	Doing explanation building	Here, the goal is to analyse the case study data by building an explanation about the case, usually to explain a phenomenon in a narrative manner.
External validity	Using replication logic	Multiple case studies that are executed in a replicated manner, provide more compelling support for the initial set of propositions when they yield similar results.
Reliability	Using a case study protocol	The protocol should contain the procedures and general rules to be followed to guide the researcher in carrying out the data collection of a case study.
	Developing a case study database	When the documentation consists of two separate collections, namely the data or evidentiary base and the research report, other persons can inspect the entire database apart from reading the report.

Using multiple sources of evidence
To increase the number of sources of evidence and with that the construct validity, we established data and method triangulation. Through data triangulation we collected information from multiple sources, while aiming to corroborate to the same finding. We used the following data sources to strengthen the case study findings: 1) the checkpoint questionnaires, 2) TAM survey, and 3) expert (group) interview.

These three data sources also allowed for a triangulation of methods. The questionnaires were analysed as document artefacts, looking at the completeness of the answers. With the help of statistical analysis, we developed the findings from the survey. Finally, we applied semi-structured interviews to contribute to the case study findings.

The common finding which all three data sources and methodological triangulation support is the proposition we established in the case study protocol. That is, the model is able to evaluate and give suggestions to improve the enterprise architecture of hospitals.

Establishing a chain of evidence
The steps we took are traceable back to the initial research questions. This is depicted in the case study research design. In this same design we also show the traceability between the case study data and the research questions is established. The execution and results show that this traceability is kept intact. These results can be found in the separate case study database.

Doing pattern matching
As we explained earlier, we logically matched the findings from the multiple sources of evidence to a predicted pattern. This predicted pattern is the proposition which we established during the draft of the case study research design and protocol. The results show that the findings can be logically linked to the proposed proposition.

Doing explanation building
During one of the case studies it was especially necessary to build an explanation. As explained in the next tactic, we replicated case studies to provide more compelling support for the proposition. However, at hospital B the participants were not able to fully use the maturity model. This can be explained because of the lack of knowledge of the participants on the enterprise architecture function of that hospital and enterprise architecture in general. Evidence for this explanation was given by the architect of that hospital, where he mentioned that that was exactly what the participants told him.

Using replication logic
As just mentioned, multiple case studies that are executed in a replicated manner provide more compelling support. We applied exactly the same protocol at all seven hospitals. We were not able to complete all seven case studies because of lack of time and effort. Nevertheless, they did follow the same protocol and therefore their findings provide more compelling support for the proposition.

Using a case study protocol
We could not execute most of the previous tactics without the use of a case study protocol. Through execution of the case studies, it became clear that the protocol was detailed enough. No alteration to the protocol was necessary after the first few case studies.

Developing a case study database
We were able to make a clear separation of the documentation. All the findings, inferences, and conclusions can be found in this research report. Whereas all the data and evidence are stored in a separate case study database. The files in the database consists of the complete questionnaires with the checkpoints, raw audio files of all interviews, transcriptions and coding of these interviews in NVivo, and the raw results of the TAM survey.

6.5 Conclusion

In this chapter we elaborated on the case studies that we performed to validate the model in hospitals. We created a multiple-case study research design and defined the protocol for executing a case study. In total, seven case studies were performed. In those case studies, 34 experts participated. Five of the seven case studies were exactly performed according to protocol. Two were not, these two were not completed at all. One of the hospitals showed a lack of effort, not being able to provide the filled in questionnaires. The other hospital did provide the filled in questionnaires but had to cancel the remaining activities in the case study because of lack of time.

Firstly, we assessed whether the participants were able to fully fill in the questionnaire with the checkpoints. Results show that 3.7% of the checkpoints were left empty, not being assessed by the participants. None of the checkpoints was left empty exceptionally more times than the others. We also checked whether the new checkpoints were left empty more than the original ones. 4% of the new checkpoints were left empty, which is a mere 0.3% higher than the overall checkpoints. From the new checkpoints, checkpoint 147 was left empty the most. This was 4 out of the 34 times, making it 11.8%. Remarkably, 143 of the 189 checkpoints that were left empty originated from hospital B. Later, we learned that they had trouble filling in the questionnaire since they did not have the adequate knowledge of the enterprise architecture function in their hospital. The questionnaires from hospital B, therefore, skewed these results.

Secondly, we assessed the following perceptions of the participants about the model: 1) the perceived usefulness, 2) the perceived ease of use, and 3) the intention to use the model. We assessed this through a survey based on the Technology Acceptance Model (TAM). In total, 26 out of the 34 participants filled out the TAM survey, making a response rate of 76.5%. They scored the three variables through 10 statements, based on a seven-point Likert scale, where 1 = strongly disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = moderately agree, and 7 = strongly agree. The internal validity between the statements per variable was calculated and was assessed high enough to merge the statements per variable. The results show that all the variables are positive. The perceived usefulness and perceived ease of use of the participants are slightly positive with a value of 4.78 and 4.63, respectively. The intention to use the enterprise architecture maturity model for hospitals is slightly higher with a value of 5.48.

Thirdly, we performed expert (group) interviews to gain additional insights from the participants. These were semi-structured and focussed on: 1) the suitability of the final profile on the enterprise architecture function of the hospital, 2) the suggestions for improvement in the final report, 3) the working method to use the enterprise architecture maturity model for hospitals, 4) the extra focus area: ‘Interoperability’, and 5) suggestions from the interviewees. All hospitals unanimously agreed with their final profile; they could relate it to their hospital. Three out of the four hospitals found the suggestions for improvement very valuable, whereas the last one had their doubts on some points. Everyone thought the working method and its result was valuable in the end, but they all had complaints about the questionnaire with the checkpoints. They also all agreed on the importance of interoperability and that it should be taken into account when assessing the enterprise architecture maturity of a hospital. Although some had small remarks on the implementation. Finally, they gave some suggestions for improving the model or its application: 1) give a scaled option to answer the checkpoints (for example 1 to 10) instead of yes/no, 2) the option to measure the level of interoperability throughout the ecosystem, 3) have the group discussion in which you come towards the final profile with everyone who filled in the questionnaire, and 4) only assess the checkpoints from the first couple of scales instead of all checkpoints in the questionnaire.

Finally, we present which threats to validity there are and which tactics we performed to reduce them. To conclude: the case studies showed that the enterprise architecture maturity model for hospitals is perceived as a valuable instrument to assess and give suggestions to improve the enterprise architecture function of a hospital. Therefore, the findings support the proposed proposition from the case study research design, that is, the model should be able to evaluate and give suggestions to improve the enterprise architecture maturity of hospitals. However, there is still some room for improvement, especially in the questionnaire with the checkpoints.

7. Discussion

In this chapter, firstly, we discuss the contributions of this research. Secondly, the limitations of the research are discussed.

7.1 Contributions

The contributions of this research are two-fold, there are scientific contributions, and practical contributions. Firstly, we discuss the scientific contributions. Secondly, practical contributions are reviewed.

7.1.1 Scientific contributions

A number of scientific contributions follow from this research. First and foremost, the main goal of this research was to design an enterprise architecture maturity model that can be used in the context of hospitals to support the improvement process of the enterprise architecture maturity. Especially the last part of the goal, supporting the improvement process, came forward as successful during the last interviews we held at the hospitals. During these interviews, we got to the bottom of the contributions of the enterprise architecture maturity model for the hospitals. And from almost all the interviews we held, it became clear that they found the suggestions for improvement to be useful. The results from the Technology Acceptance Model (TAM) survey also show a positive attitude towards the perceived usefulness of the model. This signifies that we succeeded in designing such a model, filling the gap in research which we identified in chapter 1.

However, these suggestions for improvement mostly derive from the original DyAMM. Content-wise, we can not conclude that our specific tailoring is useful for hospitals. Although we can not conclude whether the suggestions for improvement we added to the model are useful, we can conclude through multiple validations that the extra focus area is perceived to be useful. For this extra focus area, there was a positive voice throughout both focus group sessions, and all case studies. We can also conclude that the working method we derived for applying the model is a contribution to science. The method we applied is described in detail, and validated through the TAM survey and the final expert interviews. In the papers we analysed during the systematic literature review, we noticed that the method to apply these models is often not explicitly mentioned. 6 out of the 17 models we analysed do not mention a method at all. Also, the publications concerning the DyAMM also do not describe a method in this detail. With the validation of this working method of applying the enterprise architecture maturity model for hospitals, we made a contribution to science. The method can possibly be adapted to other maturity models as well. A factor which possibly contributed to this success was the survey in which we requested which possible implementation of the model the respondents would like.

As mentioned, we performed a systematic literature review (SLR) on the subject of enterprise architecture maturity models. Since the existing SLRs either focussed on a different subject, were not executed systematically, and/or were not exclusive, our SLR is a contribution to science as well. The exhaustive SLR gives an overview of the existing enterprise architecture maturity models and helps future research in this subject.

The actual tailoring process we developed and executed is proven to be a contribution to science as well. This tailoring process resulted in a paper which got accepted at the international working conference on Exploring Modeling Methods for Systems Analysis and Development (EMMSAD) (van Zwienen, Ruiz, van Steenbergen, & Burriel, 2019). This year was the 24th event of EMMSAD, which was co-located with the International Conference on Advanced Information Systems Engineering. The process is made generic so it can be applied to all maturity models in all domains.

7.1.2 Practical contributions

We also address the practical contributions, since this research project was funded through an internship at Sogeti, an IT consultancy company in the Netherlands. The DyAMM originates from this company and the findings of this research project can, therefore, help Sogeti in applying the model. As mentioned before, there is not a method for utilising the DyAMM described in as much detail in literature as we did. We also learned that Sogeti normally utilises the DyAMM in a different fashion. They do not always

give a workshop in which they compare and combine different points of view. The results of this research suggest that Sogeti can utilise the DyAMM with less interviews and still yield good results. However, it is utterly important that the correct stakeholders are involved in the process. We learned this from the case study at hospital B. During the expert interviews, we learned that the participants especially liked the part of combining the individual questionnaires with the checkpoints. By letting everyone involved fill in the questionnaire, we were able to shed light on the different viewpoints and opinions of the involved stakeholders. In some situations, unknown differences in opinions were exposed. Also, the session where we combined the results of the different questionnaires formed a good basis for the participants to discuss the enterprise architecture function of their hospital. This discussion was also mentioned as something they experienced positively. Something to take into consideration though is to adjust the structure of the questionnaire. We will discuss this in the next chapter, where we draft suggestions for improvement.

To emphasise that Sogeti can use this method as an alternative to their present method, one of the participants compared both methods. At a different organisation, he had utilised the method through a consulting project where he hired Sogeti. He mentioned that he thought that the method we followed during this research was more useful than the method Sogeti usually performs. Mainly because of the presentation of the different insights we gathered from his colleagues.

Another contribution is the extra focus area. During the validations, multiple participants mentioned that interoperability is not only important for hospitals, but also for other organisations nowadays. Therefore, there is a possibility for Sogeti to implement this extra focus area into a new version of the original DyAMM. We will also discuss this further in the next chapter.

7.2 Limitations

During this research, some limitations derived. In this chapter, we address those limitations. First of all, the model which we eventually choose to serve as a basis for the further design of the enterprise architecture maturity model for hospitals was the model which derives from the company where the internship was held. This suggests some positive discrimination bias. We tried to resolve this bias as much as possible with the systematic literature review. By making an exhaustive comparison of the existing enterprise architecture maturity models we included as many models as candidate models for tailoring as possible. We also choose the DyAMM as objectively as possible, most reasons for choosing the DyAMM derived from other research.

There is also a limitation in the design of the model itself. We placed emphasis on the requirements of three experts. There is a possibility that these requirements are subjective. It was, therefore, important to validate the design extensively. During the first focus group session though, one of the interviewees from which some of the requirements originate was present. A danger could be that the design is too much designed towards the possible subjective opinion of that participant. Luckily, all other participants in that focus group session, in the second focus group session were not interviewees from the requirements. By applying this heterogeneity, we tried to reduce this bias as much as possible. This same risk was exposed during the case studies, one of the interviewees from the requirements was also a participant in a case study. Would this have been the only case study, the results would have been biased and less generalisable. However, since we executed a multiple case study research, we reduced this bias.

We executed the tailoring process which we developed, from which a model derived that was perceived useful by the participants in the case studies. However, we can not confirm that this process is indeed applicable to other domains. The process is developed in such a style that it should be applicable in other domains, but we lack evidence on whether that actually produces useful models in other domains.

Another limitation is the fact that we do not have evidence on whether the model is actually able to improve the enterprise architecture function of a hospital. We do show evidence that the participants think the suggestions for improvement are viable suggestions, and that they see added value in these suggestions. This suggests that the model can be used to support the improvement process of the enterprise architecture maturity. However, there is no empirical evidence on whether the implementation of these suggestions actually improves the enterprise architecture maturity. To provide this kind of evidence, longitudinal research with quantifiable measures is necessary.

8. Conclusions

In this research, we analysed a gap in the research literature. We observed that there is a need for an enterprise architecture maturity model for hospitals, and the opportunity to use a reference architecture to design one. The main research questions that we answer is:

> ***"How can we design an enterprise architecture maturity model that can be used in the context of hospitals to support the improvement process of the enterprise architecture maturity?"***

The goal, therefore, was to design an enterprise architecture maturity model for hospitals. To achieve this goal, we answered multiple sub-questions.

The first sub-question we answered concerned the state-of-the-art of the literature about enterprise architecture in hospitals, and enterprise architecture maturity models. We described the notion of enterprise architecture, specifically, its benefits, maturity, and why enterprise architecture in hospitals is different from other industries. To derive all existing enterprise architecture maturity models, we performed a systematic literature review. This resulted in a list of 17 existing models. By comparing these 17 models we were able to find the model that we will use as input for the design of our model. Because of the finer granularity which provides more detail in guiding improvement, we choose the DyAMM.

The second sub-question we answered encompassed the requirements for the enterprise architecture maturity model for hospitals. These requirements derived from existing literature and from semi-structured interviews, which we held with three experts in practice. This resulted in 14 requirements. We divided the requirements into functional and non-functional requirements. Where the former concerns the function of the model, the aspects which the model should evaluate or realise. The latter concerns the operation of the model, how the model should be used. These requirements formed input for the remainder of the design.

The third sub-question we answered involved the reference architecture and how this architecture can enrich the enterprise architecture maturity model for hospitals. To answer this question, we derived a process to tailor an existing enterprise architecture maturity model to a specific domain. The process is as follows: 1) Define domain, 2) Acquire reference architecture, 3) Elicit requirements, 4) Find base maturity model, 5) Metamodel base model and reference architecture, 6) Apply lens on metamodels, 7) Cross-check requirements with reference architecture, 8) Make base model domain-specific, 9) Validate domain-specific model, and 10) Implement model.

The reference architecture we acquired was the Ziekenhuis Referentiearchitecture (ZiRA, in Dutch). The requirements were elicited as described earlier. Ditto for finding the base model. The metamodeling of the base model and reference architecture showed from which components both models were made up. By applying a lens, i.e. looking whether a component encompasses the product, or the process point-of-view of enterprise architecture, we found opportunities for enriching the base model. We learned that applying a lens on both metamodels showed to be beneficial. By crosschecking the requirements, we were able to identify which components we should integrate. The integration followed the protocol described by van Steenbergen, Bos, et al. (2010) and resulted in the first version of the enterprise architecture maturity model for hospitals. This design was validated and improved through two focus group sessions, an expert interview, and thinking aloud sessions, resulting in the final design of the enterprise architecture maturity model for hospitals.

The fourth and final sub-question concerned the validation of the performance of the model in hospitals. Through a multiple-case study research, we performed seven case studies at different hospitals. In these case studies, we assessed the performance of the model on three points. Firstly, whether we were able to fully use the model. Secondly, what the perceptions were of the participants, through a survey based on the Technology Acceptance Model (TAM). And finally, conduct expert interviews to gain additional insights.

Although we were not able to utilise the model for the full 100%, we did reach completeness of 96.3%. Most of the missing utilisation derived from a single hospital, from which we came to know that they did not understand the model nor the enterprise architecture function of their hospital good enough. 76.5% of the participants responded on the TAM survey, the perceptions of the participants were all slightly positive. From the expert interviews, we can conclude that the participants found the maturity profile which resulted from the case study to be suitable with the enterprise architecture maturity of their hospital. Also, that they appreciated the suggestions for improvement which followed from the maturity profile. Furthermore, they unanimously agreed that they enjoyed the working method of utilising the enterprise architecture maturity model for hospitals. Additionally, the extra focus area which we added to the original model was deemed important and useful in assessing the enterprise architecture maturity of a hospital. Finally, some suggestions for improving the model, or the working method, derived from these interviews.

We can, therefore, conclude that we succeeded in designing an enterprise architecture maturity model that can be used in the context of hospitals to support the improvement process of the enterprise architecture maturity. Although we must keep the limitations from the previous chapter in mind. We contributed to the scientific and practical field, as described in the previous chapter as well. Undoubtedly, there are still venues for further research and practical improvements possible, which we describe in the next section.

8.1 Future work

During this research project, we identified several venues for further research. We also received suggestions for improving the practical aspects of the enterprise architecture maturity model for hospitals. In this subchapter, we elaborate on these possibilities for future work.

It would be interesting to find out whether the process we developed for tailoring an enterprise architecture maturity model towards a specific domain is applicable to a different domain indeed. If the process would be applied to a different domain, with a different reference architecture, and possibly with a different enterprise architecture maturity model, it would become clear whether the process is indeed generically applicable. On the same side, the working method we developed for utilising the enterprise architecture maturity model can also be tested on other models.

Something that has not yet been researched at all, and which we think a good opportunity for research, is the benefit of maturing the enterprise architecture function of a hospital, or even an organisation. So far, there are no quantifiable measures or empirical evidence whether improving the maturity enables business benefits for example. A longitudinal study at the hospitals from our case studies could fill this gap. For this to succeed, quantifiable key performance indicators (KPIs) must be designed and measured at these hospitals before they implement the suggestions for improvement from the model. It is possible to construct these KPIs with inspiration from the benefit enablers identified by Tamm et al. (2011), or the enterprise architecture benefits identified by Niemi (2006). After measuring these KPIs, the suggestions for improvement should then be implemented. It would be obvious that after a certain period of time when a new maturity profile would be made up of the hospital, the maturity level of that hospital would be higher. Simply because they implement the gaps for achieving a higher maturity level. However, it would be more interesting to measure these KPIs at the same time the second maturity profile is created. When these KPIs are indeed quantifiable, you could hypothesise that improving the maturity level of a hospital increases the outcomes of the KPIs. This would provide empirical evidence of the implementation evaluation which would complete an engineering cycle as described by Wieringa (2014).

The utilisation of the model is still something which can improve significantly. From the expert interviews, several suggestions for improvement derived. A large-scale experiment could provide insight into which working method works best. For this to succeed, first, the most promising working methods should be discovered. Possible working methods are: 1) the original working method by Sogeti, where an advisor conducts interviews and studies documentation to make up a maturity profile, 2) the working method suggested in this research, 3) a questionnaire where the respondent can rate the checkpoints on a ratio scale instead of yes or no, 4) a less extensive questionnaire with only the checkpoints from the first scales, and 5) a rule-based tool which only asks the necessary checkpoints and automatically draws

up a maturity profile. It should then be assessed which working methods yields the best results. This could be validated similarly to the validation in this research, by using the TAM survey and expert interviews to gain additional insights. These should then be compared to each other for all working methods.

References

Ahsan, K., Shah, H., & Kingston, P. (2010). Healthcare modelling through enterprise architecture: A hospital case. *ITNG2010 - 7th International Conference on Information Technology: New Generations*, (March 2014), 460–465. https://doi.org/10.1109/ITNG.2010.190

Ajer, A. K. S. (2018). Enterprise Architecture in Healthcare and Underlying Institutional Logics: a Systematic Literature Review of IS Research. *Proceedings of the Twenty-Second Pacific Asia Conference on Information Systems*, (280).

Ali, Z. A., & Elnaz, B. (2012). The phenomenon of Information Technology and Enterprise Architecture of Electronics City. *Life Science Journal*, *9*(4), 4228–4234.

Arab-Mansour, I., Millet, P. A., & Botta-Genoulaz, V. (2017). A business repository enrichment process: A case study for manufacturing execution systems. *Computers in Industry*, *89*, 13–22. https://doi.org/10.1016/j.compind.2017.03.006

Bachoo, A. (2018). Enterprise architecture practices to achieve business value. *Proceedings - 2018 20th IEEE International Conference on Business Informatics*, *1*, 1–9. https://doi.org/10.1109/CBI.2018.00010

Bates, D. W. (2002). The quality case for information technology in healthcare. *BMC Medical Informatics and Decision Making*, *2*(7). https://doi.org/10.1186/1472-6947-2-1

Bates, D. W., & Gawande, A. A. (2003). Improving Safety with Information Technology. *New England Journal of Medicine*, *348*(25), 2526–2534. https://doi.org/10.1056/NEJMsa020847

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing Maturity Models for IT Management. *Business & Information Systems Engineering*, *1*(3), 213–222. https://doi.org/10.1007/s12599-009-0044-5

Bernard, S. A. (2005). *An Introduction to Enterprise Architecture* (2nd ed.). Bloomington: AuthorHouse.

Bland, J. M., & Altman, D. G. (1997). Statistics notes: Cronbach's alpha. *Bmj*, *314*(7080), 572.

Bradley, R. V., Pratt, R. M. E., Byrd, T. A., Outlay, C. N., & Wynn, D. E. (2012). Enterprise architecture, IT effectiveness and the mediating role of IT alignment in US hospitals. *Information Systems Journal*, *22*(2), 97–127. https://doi.org/10.1111/j.1365-2575.2011.00379.x

Bradley, R. V., Pratt, R. M. E., Byrd, T. A., & Simmons, L. L. (2011). The Role of Enterprise Architecture in the Quest for IT Value. *MIS Quarterly Executive*, *10*(2), 73–80.

Budgen, D., & Brereton, P. (2006). Performing Systematic Literature Reviews in Software Engineering. In *Proceedings of the 28th International Conference on Software Engineering* (pp. 1051–1052). ACM.

Bygstad, B., Hanseth, O., & Truong Le, D. (2015). From IT Silos to Integrated Solutions. A Study in E-Health Complexity. *Proceedings of the Twenty-Third European Conference on Information Systems*, (23).

C4ISR Architectures Working Group. (1998). *Levels of Information Systems Interoperability (LISI)*. Washington, DC.

Carvalho, J. V., Rocha, Á., & Abreu, A. (2016). Maturity Models of Healthcare Information Systems and Technologies: a Literature Review. *Journal of Medical Systems*, *40*(6), 1–10. https://doi.org/10.1007/s10916-016-0486-5

Chen, D., & Vernadat, F. B. (2003). Enterprise Interoperability: A Standardisation View. *Enterprise Inter- and Intra-Organizational Integration*, 273–282. https://doi.org/10.1007/978-0-387-35621-1

Chrissis, M. B., Konrad, M., & Shrum, S. (2003). *CMMI guidelines for process integration and product improvement*. Addison-Wesley.

Clark, T., & Jones, R. (1999). Organisational Interoperability Maturity Model for C2. *Proceedings of the 1999 Command and Control Research and Technology Symposium*.

Curley, M. (2008). Introducing an IT capability maturity framework. *Lecture Notes in Business Information Processing*, *12 LNBIP*, 63–78. https://doi.org/10.1007/978-3-540-88710-2_6

De Bruin, T., Freeze, R., Kaulkarni, U., & Rosemann, M. (2005). Understanding the Main Phases of Developing a Maturity Assessment Model. *16th Australasian Conference on Information Systems (ACIS) 29 Nov – 2 Dec 2005, Sydney*, 8–19. https://doi.org/10.1108/14637151211225225

Executive Office of the President of the US - Office of Management and Budget. (2009). *Improving Agency Performance Using Information and Information Technology (Enterprise Architecture Assessment Framework v3.1)*.

Galliers, R. D., & Sutherland, A. R. (1991). Information systems management and strategy formulation: the 'stages of growth' model revisited. *Information Systems Journal*, *1*(2), 89–114.

https://doi.org/10.1111/j.1365-2575.1991.tb00030.x

Gandhi, P., Khanna, S., & Ramaswamy, S. (2016). Which Industries Are the Most Digital (and Why)? Retrieved from https://hbr.org/2016/04/a-chart-that-shows-which-industries-are-the-most-digital-and-why

Gebre-Mariam, M., & Bygstad, B. (2016). The Organizational Ripple Effect of IT Architecture in Healthcare. *Proceedings of the Twenty-Fourth European Conference on Information Systems*. https://doi.org/10.1385/MB:31:2:129

Gökalp, E., & Demirörs, O. (2014). Government process capability model: An exploratory case study. *Communications in Computer and Information Science*, *477*, 94–105. https://doi.org/10.1007/978-3-319-13036-1_9

Herz, T. P., Hamel, F., Uebernickel, F., & Brenner, W. (2011). Towards a Multisourcing Maturity Model as an Instrument of IT Governance at a Multinational Enterprise. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 1–10. https://doi.org/10.1109/HICSS.2011.448

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105.

Hjort-Madsen, K. (2006). Enterprise Architecture Implementation and Management: A Case Study on Interoperability. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06)*, *00*(C), 1–10. https://doi.org/0-7695-2507-5

ISACA. (2018). *COBIT 2019 Framework: Introduction and Methodology*.

Kaisler, S. H., Armour, F., & Valivullah, M. (2005). Enterprise Architecting: Critical Problems. *Proceedings of the 38th Annual Hawaii International Conference on System Sciences*, 1–10. https://doi.org/10.1109/HICSS.2005.241

Khoshgoftar, M., & Osman, O. (2009). Comparison of maturity models. In *International Conference on Computer Science and Information Technology* (pp. 297–301). IEEE.

Koomen, T., & Pol, M. (1999). *Test Process Improvement, a practical step-by-step guide to structured testing*. Boston: Addison-Wesley.

Lakhrouit, J., & Baïna, K. (2013). State of the art of the maturity models to an evaluation of the enterprise architecture. *3rd International Symposium ISKO-Maghreb*, 1–8. https://doi.org/10.1109/ISKO-Maghreb.2013.6728119

Lankhorst, M. (2017). *Enterprise Architecture at Work*. Berlin: Springer. https://doi.org/10.1007/978-3-662-53933-0

Luftman, J. (2000). Assessing Business-IT Alignment Maturity. *Communications of the Association for Information Systems*, *4*(14), 1–51.

Maxwell, J. A. (2013). *Qualitative Research Design: An Interactive Approach*. Thousand Oaks, CA: Sage publications. https://doi.org/10.3724/SP.J.1042.2015.01869

Mc Caffery, F., Casey, V., Sivakumar, M. S., Coleman, G., Donelly, P., & Burton, J. (2012). Software and systems traceability. *Software and Systems Traceability*, 321–339. https://doi.org/10.1007/978-1-4471-2239-5

Mettler, T., & Rohner, P. (2009). Situational maturity models as instrumental artifacts for organizational design. *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology - DESRIST '09*, 1. https://doi.org/10.1145/1555619.1555649

Meyer, M., Helfert, M., & O'Brien, C. (2011). An analysis of enterprise architecture maturity frameworks. *Lecture Notes in Business Information Processing*, *90 LNBIP*, 167–177. https://doi.org/10.1007/978-3-642-24511-4_13

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. Thousand Oaks, CA: Sage publications. https://doi.org/10.1017/S0033291715001245

Morgan, D. L. (1996). *Focus Groups as Qualitative Research* (Vol. 16). Sage publications. https://doi.org/10.4135/9781412984287

National Association of State Chief Information Officers. (2003). *NASCIO Enterprise Architecture Maturity Model, Version 1.3*.

NATO. (2003). *NATO C3 Technical Architecture*.

Niemi, E. (2006). Enterprise architecture benefits: Perceptions from literature and practice. In *Proceedings of the 7th IBIMA Conference Internet & Information Systems in the Digital Age*. Brescia, Italy.

Nikpay, F., Ahmad, R., Rouhani, B. D., & Shamshirband, S. (2016). A systematic review on post-implementation evaluation models of enterprise architecture artefacts. *Information Systems Frontiers*, 1–20. https://doi.org/10.1007/s10796-016-9716-0

Nolan, R. L. (1973). Managing the Computer Resource: A Stage Hypothesis. *Communications of the ACM*, *16*(7), 399–405.

Nolan, R. L. (1979). Managing the crisis in data processing. *Harvard Business Review*, *57*(2), 115–126.

Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron? *Quality and Quantity*, *41*(2), 233–249. https://doi.org/10.1007/s11135-006-9000-3

Panetto, H. (2007). Towards a classification framework for interoperability of enterprise applications. *International Journal of Computer Integrated Manufacturing*, *20*(8), 727–740. https://doi.org/10.1080/09511920600996419

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

Pereira, C. M., & Sousa, P. (2004). A method to define an Enterprise Architecture using the Zachman Framework. *Proceedings of the 2004 ACM Symposium on Applied Computing - SAC '04*, (June), 1366–1371. https://doi.org/10.1145/967900.968175

Plessius, H., Slot, R., & Pruijt, L. (2012). On the categorization and measurability of enterprise architecture benefits with the enterprise architecture value framework. *Lecture Notes in Business Information Processing*, *131 LNBIP*, 79–92. https://doi.org/10.1007/978-3-642-34163-2_5

Pries-Heje, J., Baskerville, R., & Venable, J. R. (2008). Strategies for design science research evaluation. *European Conference on Information Systems 2008 Proceedings*, (87). Retrieved from http://aisel.aisnet.org/ecis2008/87

Proenca, D., & Borbinha, J. (2017). Enterprise architecture: A maturity model based on TOGAF ADM. *Proceedings - 2017 IEEE 19th Conference on Business Informatics*, *1*, 257–266. https://doi.org/10.1109/CBI.2017.38

Raghupathi, W., & Tan, J. (2002). Strategic IT Applications in Health Care. *Communications of the ACM*, *45*(12).

Richardson, G. L., Jackson, B. M., & Dickson, G. W. (1990). A Principles-Based Enterprise Architecture: Lessons from Texaco and Star Enterprise. *MIS Quarterly*, *14*(December), 385. https://doi.org/10.2307/249787

Robertson, E., Peko, G., & Sundaram, D. (2018). Enterprise Architecture Maturity: A Crucial Link in Business and IT Alignment. In *PACIS 2018 Proceedings*.

Romanow, D., Cho, S., & Straub, D. (2012). Riding the Wave: Past Trends and Future Directions for Health IT Research. *MIS Quarterly*, *36*(3), iii–x.

Ross, J. W. (2003). Creating a Strategic IT Architecture Competency: Learning in Stages. *MIT Sloan Working Paper No. 4314-03; Center for Information Systems Research Working Paper No. 335.* Retrieved from http://ssrn.com/abstract=416180

Ross, J. W., & Beath, C. M. (2006). Sustainable IT Outsourcing Succes: Let Enterprise Architecture Be Your Guide. *MIS Quarterly Executive*, *5*(4), 181–192.

Ross, J. W., Weill, P., & Robertson, D. C. (2006). *Enterprise Architecture as Strategy: Creating a Foundation for Business Execution*. Boston, Massachusetts: Harvard Business School Press.

Schekkerman, J. (2006). *Extended Enterprise Architecture Maturity Model: Support Guide (Version 2.0)*.

Segars, A. H., & Grover, V. (1996). Designing Company-wide Information Systems: Risk Factors and Coping Strategies. *Long Range Planning*, *29*(3), 381–392. https://doi.org/10.1016/0024-6301(96)00024-6

Sobczak, A. (2013). Methods of the assessment of enterprise architecture practice maturity in an organization. *Lecture Notes in Business Information Processing*, *158 LNBIP*, 104–111. https://doi.org/10.1007/978-3-642-40823-6

Software Engineering Institute of Carnegie Mellon. (2011). *Standard CMMI Appraisal Method for Process Improvement (SCAMPI) Version 1.3: Method Definition Document*. https://doi.org/CMU/SEI-2011-HB-001

Spewak, S. H., & Hill, S. C. (1993). *Enterprise Architecture Planning: Developing a Blueprint for Data, Applications, and Technology* (2nd ed.). Wiley.

Tamm, T., Seddon, P. B., Shanks, G., & Reynolds, P. (2011). How Does Enterprise Architecture Add Value to Organisations? *Communications of the Association for Information Systems*, *28*(1), 141–168. https://doi.org/10.17705/1CAIS.02810

ten Harmsen van der Beek, W., Trienekens, J., & Grefen, P. (2012). The application of enterprise reference architecture in the financial industry. *Lecture Notes in Business Information Processing*, *131 LNBIP*,

93–110. https://doi.org/10.1007/978-3-642-34163-2_6

Tolk, A., & Muguira, J. A. (2003). The Levels of Conceptual Interoperability Model A Traditional View of Levels of Information Systems Interoperability The Levels of Conceptual Interoperability. *Proceedings of the 2003 Fall Simulation Interoperability Workshop*, *7*, 1–11.

Törmer, R. L., & Henningsson, S. (2017). How Enterprise Architecture Maturity Enables Post-Merger IT Integration. In *Lecture Notes in Business Information Processing* (Vol. 295, pp. 16–30). https://doi.org/10.1007/978-3-319-64930-6_2

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*(3), 207–222. https://doi.org/10.1111/1467-8551.00375

Trieu, V. (2013). Extending the theory of effective use: The impact of enterprise architecture maturity stages on the effective use of business intelligence systems. In *International Conference on Information Systems*.

United States Department of Commerce. (2007). *Enterprise Architecture Capability Maturity Model, Version 2.0*.

United States Government Accountability Office. (2010). *Organizational Transformation: A Framework for Assessing and Improving Enterprise Architecture Management (Version 2.0)*.

Vallerand, J., Lapalme, J., & Moïse, A. (2017). Analysing enterprise architecture maturity models: a learning perspective. *Enterprise Information Systems*, *11*(6), 859–883. https://doi.org/10.1080/17517575.2015.1091951

van de Weerd, I., Bekkers, W., & Brinkkemper, S. (2010). Developing a Maturity Matrix for Software Product Management. *Lecture Notes in Business Information Processing*, *LNBIP 51*, 76–89. https://doi.org/10.1007/978-3-642-13633-7

van de Wetering, R., & Batenburg, R. (2009). A PACS maturity model: A systematic meta-analytic review on maturation and evolvability of PACS in the hospital enterprise. *International Journal of Medical Informatics*, *78*(2), 127–140. https://doi.org/10.1016/j.ijmedinf.2008.06.010

van den Berg, M., & van Steenbergen, M. (2006). *Building an Enterprise Architecture Practice*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4020-5606-2

van der Raadt, B., Slot, R., & van Vliet, H. (2007). Experience Report: Assessing a Global Financial Services Company on its Enterprise Architecture Effectiveness Using NAOMI. *Hicss*, 218. Retrieved from http://dx.doi.org/10.1109/HICSS.2007.217

van der Raadt, B., & van Vliet, H. (2009). Assessing the Efficiency of the Enterprise Architecture Function. *Proceedings of the 1st NAF Academy Working Conference on Practice-Driven Research on Enterprise Transformations (PRET 2009), Held at CAiSE 2009*, *28*, 63–83. https://doi.org/10.1007/978-3-642-01859-6_5

van Eck, P., Blanken, H., & Wieringa, R. (2004). Project GRAAL : Towards Operational Architecture Alignment. *Journal of Cooperative Information Systems*, *13*(3), 235–255.

van Solingen, R., & Berghout, E. (1999). *The Goal/Question/Metric Method: a practical guide for quality improvement of software development*. London: McGraw-Hill. https://doi.org/10.1002/tcr.201090014

van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. C. (1994). *The think aloud method: a practical guide to modelling cognitive processes*. Academic Press, London.

van Steenbergen, M., Bos, R., Brinkkemper, S., van de Weerd, I., & Bekkers, W. (2010). The Design of Focus Area Maturity Models. *DESRIST 2010*, 317–332. https://doi.org/10.1007/978-3-642-13335-0_22

van Steenbergen, M., Bos, R., Brinkkemper, S., van de Weerd, I., & Bekkers, W. (2013). Improving IS Functions Step by Step: The Use of Focus Area Maturity Models. *Scandinavian Journal of Information Systems*, *25*(2), 35–56. Retrieved from http://aisel.aisnet.org/sjis/vol25/iss2/2

van Steenbergen, M., Schipper, J., & Brinkkemper, S. (2010). The Dynamic Architecture Maturity Matrix: Instrument Analysis and Refinement. *Service-Oriented Computing. ICSOC/ServiceWave 2009 Workshops*, 48–61.

van Steenbergen, M., van den Berg, M., & Brinkkemper, S. (2007). A Balanced Approach to Developing the Enterprise Architecture Practice. *International Conference on Enterprise Information Systems*, 240–253. Retrieved from http://link.springer.com/10.1007/978-3-642-40654-6

van Zwienen, M., Ruiz, M., van Steenbergen, M., & Burriel, V. (2019). A Process for Tailoring Domain-Specific Enterprise Architecture Maturity Models. *Enterprise, Business-Process and Information Systems Modeling. BPMDS 2019, EMMSAD 2019. Lecture Notes in Business Information Processing, Vol 352, 1*, 196–211. https://doi.org/10.1007/978-3-030-20618-5_14

Venable, J., Pries-Heje, J., & Baskerville, R. (2012). A Comprehensive Framework for Evaluation in Design Science Research. *DESRIST 2012*, 423–438. https://doi.org/10.1007/978-3-642-29863-9

Venkatesh, V., Bala, H., Venkatraman, S., & Bates, J. (2007). Enterprise architecture maturity: The story of the Veterans Health Administration. *MIS Quarterly Executive*, *6*(2), 79–90.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Vessey, I., & Ward, K. (2013). The Dynamics of Sustainable IS Alignment: The Case for IS Adaptivity. *Journal of the Association for Information Systems*, *14*(6), 283–311.

Wagter, R., Proper, H. A., & Witte, D. (2012). The Extended Enterprise Coherence-Governance Assessment. In *Trends in enterprise architecture research and practice-driven research on enterprise transformation* (pp. 218–235). Springer Berlin Heidelberg.

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, *26*(2), xiii–xxiii. https://doi.org/10.1.1.104.6570

Weiss, M. (2010). APC Forum: Creating a Platform for Innovation at Leviton Manufacturing. *MIS Quarterly Executive*, *9*(1), 35–36.

Wendler, R. (2012). The maturity of maturity model research: A systematic mapping study. *Information and Software Technology*, *54*(12), 1317–1339. https://doi.org/10.1016/j.infsof.2012.07.007

Wieringa, R. J. (2014). *Design Science Methodology*. Springer.

Wilson, E. V., & Lankton, N. K. (2004). Interdisciplinary Research and Publication Opportunities In Information Systems and Healthcare. *Communications of the Association for Information Systems*, *14*, 332–343.

Winter, R., & Fischer, R. (2006). Essential Layers, Artifacts, and Dependencies of Enterprise Architecture. In *2006 10th IEEE International Enterprise Distributed Object Computing Conference Workshops (EDOCW'06)* (Vol. 49). IEEE. https://doi.org/10.1109/EDOCW.2006.33

Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. In *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE '14* (Vol. 96, pp. 1–10). New York, New York, USA: ACM Press. https://doi.org/10.1145/2601248.2601268

Yin, R. K. (2015). *Case Study Research: Design and Methods* (5th ed.). Sage publications.

Zachman, Ja A. (1997). Enterprise architecture: The issue of the century. *Database Programming and Design*, *10*(3), 13.

Zachman, John A. (1987). A framework for information systems architecture. *IBM Systems Journal*, *26*(3), 276–292.

Appendix A: ZiRA metamodel in ArchiMate (in Dutch)

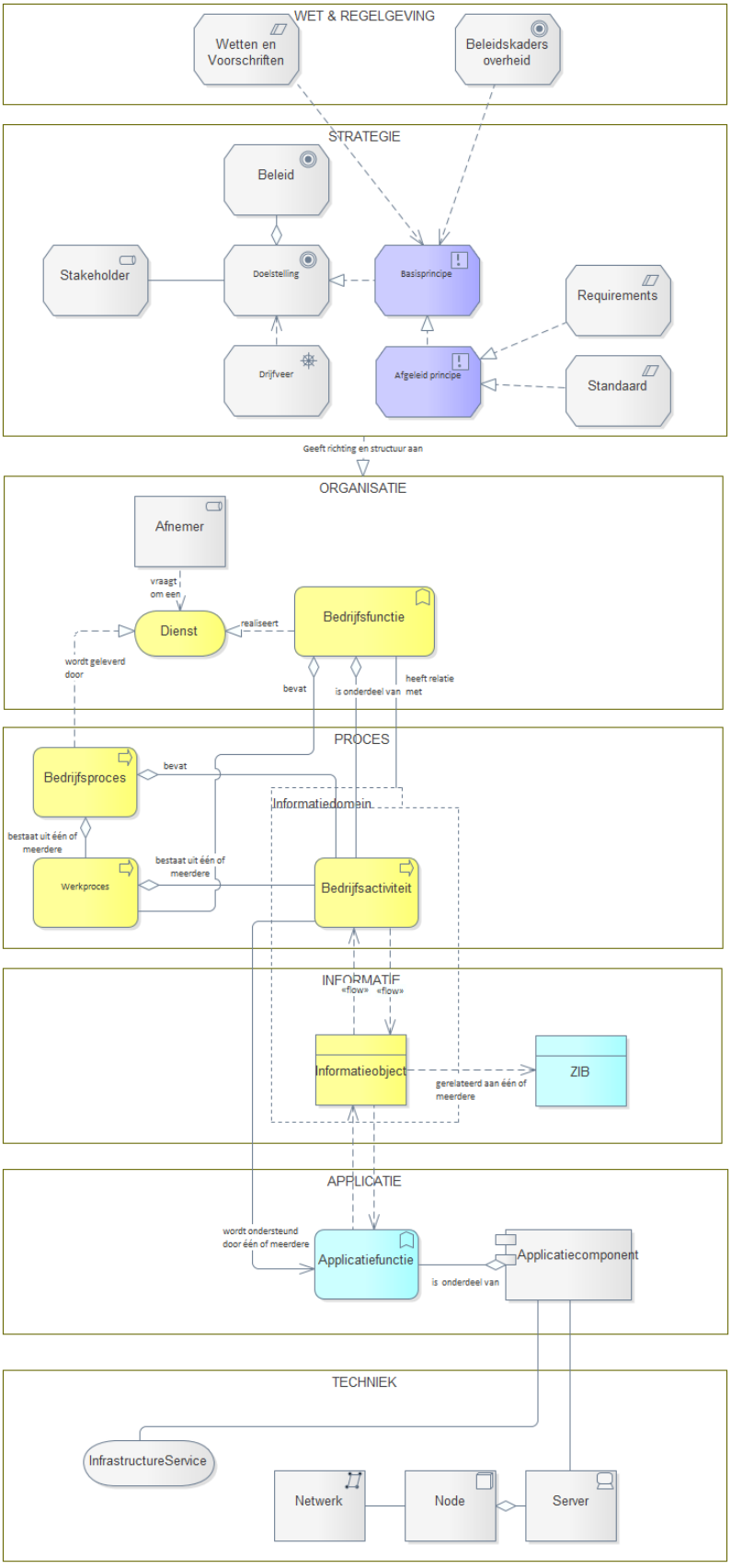

Figure 39: Metamodel of the ZiRA in ArchiMate in Dutch

Appendix B: Checkpoints from DyAMM and their domain

Table 80: Checkpoints from the DyAMM per capability and focus area with their domain (adapted from van den Berg & van Steenbergen (2006))

#	Focus Area	Level	Domain	Checkpoints
1	1	A	Both	An architectural document will only be drafted if there is someone in need of the result
2	1	A	Process	Prior to developing the architectural models and principles, it is determined who will be using the result
3	1	A	Product	The architecture addresses issues that are relevant to the organisation
4	1	B	Both	All relevant parties are involved in the development of the architectural models and principles (e.g. business managers, administrators, developers, line staff)
5	1	B	Product	The architecture shows how the stakeholders' interests have been addressed
6	1	B	Product	The non-functional requirements are adequately incorporated in the architectural models and principles
7	1	B	Both	A distinction is made between enterprise architecture and project architecture
8	1	C	Both	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture
9	1	C	Process	An effective form of requirement management is in place for all constituent architectures relevant to the organisation
10	1	C	Product	The architecture covers the relevant segments of the organisation (i.e. those segments for which it is desirable to have direction)
11	1	C	Both	The enterprise architecture and project architectures are consistent with each other
12	2	A	Process	The architecture is acknowledged by management.
13	2	A	Product	The architecture offers a clear picture of what the organisation wants.
14	2	A	Both	The architecture can be accessed by all employees.
15	2	B	Process	The architecture is used to give direction to business and IT developments
16	2	B	Both	The architecture provides guidelines at the correct level that can be followed during a project's execution
17	2	B	Product	The architecture has a clear status
18	2	C	Process	Architecture plays an integral role in the organisation’s decision-making process
19	2	C	Process	The vision that serves as the basis for the architecture is shared by general management
20	2	C	Process	The ownership of processes, data and information systems has been effectively arranged
21	3	A	Process	The relationship between the architectural choices and the organisation’s business objectives is clear
22	3	A	Process	The architectural choices are in line with the business strategy and objectives
23	3	B	Process	Architects and business representatives do not hesitate to get in touch with one another
24	3	B	Both	Concrete business objectives form the immediate cause for the development of the architectural models and principles
25	3	B	Both	When developing architectural models and principles, it is clear to what business objectives the architecture needs to contribute
26	3	C	Process	If the business intends to make changes, it automatically involves architects as a partner in the discussion.
27	3	C	Process	When giving shape to changes, the business feels supported by the architects.
28	3	C	Process	The architects proactively bring relevant trends and developments in the market to the attention of business management.
29	4	A	Process	There are projects that take the architecture into account.
30	4	A	Both	Staff working on projects occasionally ask questions about the architecture.
31	4	A	Process	Architects are occasionally involved in design and construction.
32	4	B	Process	Architecture has a place within the standard development process
33	4	B	Process	The architects pay specific attention to the architecture’s practical value for projects.
34	4	B	Both	The architecture is taken into account when making changes (maintenance).
35	4	C	Process	The architectural process is regularly provided with feedback by the development process.

36	4	C	Both	The architects help the developers to tailor the general architectural principles to their specific situation.
37	4	C	Process	The architectural process is regularly provided with feedback by the maintenance function.
38	5	A	Both	The architecture pays attention to the current situation (existing processes, organisational structure, information systems and technical infrastructure).
39	5	A	Process	Policy has been formulated with regard to the current situation (existing processes, organisational structure, information systems and technical infrastructure).
40	5	A	Both	Guidelines have been formulated for the maintenance of systems that do not meet the requirements of the target architecture.
41	5	B	Product	The architecture indicates the relationship between the existing situation and the desired situation.
42	5	B	Product	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation).
43	5	B	Product	The architecture clearly distinguishes between different planning horizons.
44	5	B	Product	There is an up-to-date description of the current situation (existing processes, organisational structure, information systems and technical infrastructure).
45	6	A	Both	The responsibility for the content of the architecture as a whole has been explicitly assigned to someone in the organisation.
46	6	A	Both	Each architectural product has an owner (responsible for the content).
47	6	A	Both	The content of the architecture has an official status within the organisation.
48	6	B	Process	The organisation has a body where decisions relating to the architecture can be taken (an architecture board, for instance).
49	6	B	Process	The responsibility for the architectural process as a whole has been explicitly assigned to someone in the organisation.
50	6	C	Process	Architecture is included in the portfolio of one of the members of the senior management team.
51	6	C	Process	Architecture is also the responsibility of business management.
52	6	C	Process	The manager responsible for architecture is held accountable for the extent to which architecture contributes to the business objectives.
53	7	A	Both	The architecture is used as a guideline within individual projects for making design choices that are in line with the other developments within the organisation.
54	7	A	Process	Architecture is used to prevent projects from carrying out work that has already been done.
55	7	A	Process	Before a project is started up, it is first checked how it will fit within existing and planned developments.
56	7	B	Both	The architecture is used to realise integral coordination between all current and scheduled projects.
57	7	B	Both	The architecture is used to distribute development activities among the projects.
58	7	C	Both	The architects are involved in the building of a change portfolio on the basis of the strategic objectives.
59	8	A	Both	Whether projects take the architecture into account is noticed
60	8	A	Both	Deviations from the architecture are recorded.
61	8	B	Both	Mechanisms are in place to stimulate compliance with the architecture (e.g. as part of the project management method or by way of formal reviews)
62	8	B	Both	Actions are taken to ensure that projects satisfy the requirements of the architecture (e.g. communication sessions or trainings).
63	8	B	Both	Deviations from the architecture are actively managed (e.g. in an architecture board).
64	8	C	Process	Architectural compliance is part of the project assignment.
65	8	C	Process	Architectural compliance is a matter of course in a project.
66	8	C	Both	There are processes in place for the conscious and controlled exemption – in incidental cases – of projects from the need to comply with the architecture.
67	9	A	Both	Attempts are made to review the architectural models and principles in some way or other with regard to quality.
68	9	A	Both	Quality standards have been formulated for the architecture.
69	9	B	Both	The organisation pays structural attention to the quality of the architecture.
70	9	B	Process	The organisation has set up a quality assurance programme for the architecture.
71	9	C	Both	The quality of the architecture is part of a general organisation-wide quality assurance policy

72	9	C	Process	The organisation pays structural attention to the effect of the architectural practice (examining, for example, to which extent having an architectural practice contributes to the achievement of its strategic and business objectives).
73	9	C	Both	When thinking about architecture in terms of quality, the relationship between architecture and the other processes within the organisation is taken into account (e.g. strategy formation processes, development processes and by assigning responsibility for the quality assurance to an audit service).
74	9	C	Process	Afterwards, it is possible to determine on the basis of registrations how the assurance of the architectural quality took place.
75	10	A	Process	The architectural process has been described
76	10	A	Process	The organisation is acquainted with the architectural process.
77	10	A	Process	It is occasionally checked whether the architectural process still meets the organisation's needs.
78	10	B	Process	Management procedures have been set up for the architectural process.
79	10	B	Process	Responsibility for the management of the architectural process has been assigned within the organisation.
80	10	B	Process	Changes in the architectural process are immediately communicated to the relevant stakeholders.
81	10	C	Process	The architectural process is evaluated according to a regular cycle.
82	10	C	Process	A mechanism has been introduced for the submission of improvement proposals for the architectural process.
83	10	C	Process	Improvement proposals regularly result in actual modifications to the architectural process.
84	11	A	Both	It is occasionally checked whether the architecture is still up to date.
85	11	A	Both	Outdated components are removed from the architecture.
86	11	A	Both	A new version of the architecture is published from time to time.
87	11	B	Both	A management procedure has been formulated for architectural products
88	11	B	Both	The organisation has a procedure for dealing with change proposals for architectural products.
89	11	B	Both	Management of the architectural products has been included in the architect's job responsibilities.
90	11	B	Both	Changes to the architecture are immediately communicated to all relevant stakeholders.
91	11	C	Both	There is policy in place outlining the management of the architecture
92	11	C	Both	The organisation differentiates between how different components of the architecture are managed.
93	12	A	Process	Architecture is viewed as an important issue by the IT management.
94	12	A	Process	Budget and time are structurally allocated to architecture.
95	12	B	Process	Business and IT management promote architecture as an inextricable component of business and IT projects
96	12	B	Both	Management bases its policies on time, money and quality considerations, in which compliance with architectural requirements is viewed as an essential aspect of quality.
97	12	C	Process	Architects are supported by management in the ongoing improvement of the architectural process.
98	12	C	Process	Architecture is viewed by general management as a strategic issue.
99	13	A	Process	The role of architect exists within the organisation.
100	13	A	Process	The architects can explain the architecture's added value for the organisation.
101	13	B	Process	The architects's tasks and responsibilities have been laid down.
102	13	B	Process	The architects have the required knowledge.
103	13	B	Process	The architects have the required skills.
104	13	C	Both	The architect is supported with methods and tools.
105	13	C	Process	Training programmes have been defined for the architects.
106	13	C	Process	The exchange of best practices is supported.
107	13	D	Process	The organisation has an educational plan for architects.
108	13	D	Process	The organisation has a career path for architects.
109	14	A	Both	The architects have adopted certain conventions for describing architecture.

110	14	A	Both	The architects have a good idea of which components the architecture should contain.
111	14	B	Both	There is a shared architectural method within the organisation.
112	14	B	Both	The basic ideas of the prescribed architectural method are adhered to when developing architectural models and principles.
113	14	B	Both	During the development of architectural models and principles, possible deviations from the prescribed architectural method are substantiated and documented.
114	14	C	Product	The architectural method distinguishes a variety of perspectives for describing the architecture to different stakeholders.
115	14	C	Product	The architectural method establishes a relationship between the architecture and the organisation's change processes.
116	15	A	Process	There is structural interaction between the architects.
117	15	A	Process	The architects do not hesitate to get in touch with one another.
118	15	A	Process	The architects share a common perspective on architecture.
119	15	A	Process	Activities are effectively distributed among the architects.
120	15	B	Process	The organisation's employees have a genuine interest in the architecture.
121	15	B	Process	The architects effectively communicate with the organisation regarding relevant developments in the architectural area.
122	15	B	Process	The architects enjoy sufficient visibility and credibility within the organisation.
123	15	C	Process	The architectural stakeholders have the required knowledge and skills to effectively work with architecture.
124	15	C	Process	The architectural stakeholders assume responsibility for the development and application of the architecture.
125	16	A	Both	Architectural tools are used to record and maintain the architecture
126	16	B	Both	All architects use the same tools
127	16	B	Both	Responsibility for the management of the architectural tools has been explicitly assigned within the organisation.
128	16	B	Both	The architectural tools support the architectural process.
129	16	C	Product	The architectural tools that are used are all integrated with one another.
130	16	C	Product	The mutual consistency of architectures can be checked with the aid of the architectural tools.
131	17	A	Both	A plan is drawn up prior to the development of architectural models and principles.
132	17	A	Process	The progress of an architectural development process is monitored.
133	17	B	Process	There is a standard budgeting and planning method in place for architectural development processes.
134	17	B	Process	During an architectural development process, deviations from the established budgeting and planning are substantiated and documented.
135	17	C	Process	There is a structured process for collecting feedback regarding the budgeting and planning method adopted for architectural development processes.
136	17	C	Process	Statistical data about budgets and plans that have been made for architectural development processes in the past are available.

Appendix C: Suggestions of improvement from DyAMM

Table 81: Suggestions for improvement from the DyAMM per capability and focus area (adapted from van den Berg & van Steenbergen (2006))

#	Focus Area	Level	Suggestion for improvement
1	1	A	Arrange for a sponsor. Ensure that the primary sponsor for any architecture being developed is explicitly indicated. Take the task of finding a sponsor seriously. This means that the sponsor should be actively involved in the development of the architecture.
2	1	A	Take a goal-oriented approach to developing architecture. Establish the architectural product that is needed. Determine who wants to have this product, who will be using the product and to what end, and which aspects the product has to address to satisfy these demands. It is useful to document this in a one-page document. Discuss this with the relevant stakeholders and execute it.
3	1	B	Multidisciplinary teams. Perform the actual development of architectural principles and models within multidisciplinary teams, ensuring participation of all relevant stakeholders. Make sure the stakeholders share responsibility for the overall result.
4	1	B	Workshops. Involve busy stakeholders by inviting them to workshops. Let others (architects) do the detailed elaboration.
5	1	B	Make choices traceable. Make explicit for each architectural choice the rationale behind it and whose concern is addressed by this rationale. This can be done by including the rationale in the descriptions of the architecture principles and/or by connecting principles to each other, for instance in a chain matrix. Models must contain an explicit description of the underlying reasoning and motivation.
6	1	C	Demonstrate architectural coherence. Demonstrate the coherence between architectures by making the relationships among the various architectures in the hospital apparent. The DYA framework can be used for this purpose. By positioning all the architectures in this framework, it is possible to reveal overlap and gaps.
7	1	C	Review teams. Have architectural products reviewed by at least two architects from architectural domains that are related to the architectural domain described.
8	1	C	Manage requirements. Introduce and maintain an architecture requirements document that contains the requirements on the architecture.
9	2	A	Publish the architecture. Ensure that the existing architectures are brought to the attention of the hospital. Publish the architecture on a site that is accessible to the entire hospital. Make the site attractive and interactive, for instance in the form of a (semantic) wiki. Present the architecture as representing the vision of where the hospital ultimately wants to go.
10	2	A	Story telling. Develop an inspiring story that tells why the architecture is there and why it is as it is. In other words, the vision behind the architecture. Ensure that all architects can tell this story in an inspiring way.
11	2	B	Implement project-start architecture. Supply each project with a projectstart architecture. Project-start architectures are formulated so that they are accessible, understandable and applicable to projects. Project-start architectures also establish the frameworks that give effective direction to the decisions made in projects.
12	2	B	Versioning of architecture documents. Provide architecture documents with a number of attributes concerning versioning. In addition to the status of the document, the 'sell by' date is a useful attribute: the date until which the given status is valid. Ensure that the person who maintains the document receives a signal to renew the sell by date in time. Also provide an owner of the document.
13	2	C	Incorporate architecture into the planning and control cycle. Incorporate the role of architecture into the hospital's planning and budgeting cycle. This means that, in formulating annual plans, architectural factors are considered when projects and programs are being selected. In practice, this mostly occurs by involving a member of the architect team in planning.
14	3	A	Explain the basis of the architecture. Examine the existing architecture and relate choices and statements to the business strategy and goals (to the extent that this has not already been done). If such a relationship cannot be established, take a very critical look at the architectural principles and models. Frequently, choices and statements are made in the architecture without any reference to business goals and requirements. As a consequence, these choices are constantly being questioned.
15	3	B	Set up account management for business. Initiate dialogue with business managers and their representatives, such as the information managers of the business units. This can be done by allocating business domains to the architects. The architects build up a lasting, structural relationship with their "accounts." They come to know what is going on inside the given business domain, where the needs are and how architecture can contribute to the achievement of the business goals.
16	3	C	Involve architecture in the pre-project phase (Strategic Dialogue). To begin with, collaborate with business management to determine what the added value of architecture has to be for the hospital. Based on this determination, establish the added value of architecture in the business discussions leading up to the initiation of projects – in formulating the business cases, for example. This added

			value is mostly to be found in the rapid provision of insight concerning the consequences of choices and the manner of achieving business goals.
17	3	C	Set up issue management. Make an agreement with the business managers that the architect team will take on the task of monitoring difficult issues. This means that the architect team will prepare and coordinate the handling and resolution of these issues with business management, and incorporate the results into policy. Of course, the resolved issues are also immediately converted into architecture.
18	3	C	Thinking outside in. Train the architects to think outside in, i.e. to think from the perspective of business issues instead of from the perspective of architecture. If necessary, have the architects attend relevant business courses.
19	4	A	Discuss the role of architecture with project managers. With the project managers, discuss what the relationship is between architecture and projects, why architecture is important and what this means for project execution. For example, have an architect discuss this at a project managers' work meeting.
20	4	A	Discuss the role of architecture with maintenance. With functional/technical management, discuss what the relationship is between architecture and maintenance, why architecture is important and what this means for maintenance. For example, have an architect discuss this at a work meeting.
21	4	A	Involve design and operations. Involve design and maintenance in the architecture processes. One way to do this, is to invite senior employees to participate in an architecture community.
22	4	B	Embed architecture in the project method. Many hospitals have a method for working on projects. This can be a standard method, such as PRINCE2, but it can also be the hospital's own procedure as laid out in a project manual. Give architecture a place in this procedure by literally writing it into the standard project work procedure. The role of architecture is therefore explicitly added to the project method.
23	4	B	Embed architecture in maintenance procedures. Include the role of architecture in the description of maintenance procedures. For instance, describe how and when change requests are subjected to an architecture review.
24	4	C	Set up account management for the development process. Initiate regular meetings between members of the architect team and representatives from system development. The purpose of these meetings is to ensure good collaboration between architects and projects.
25	4	C	Set up account management for maintenance. Initiate regular meetings between members of the architect team and representatives from functional/technical management. One purpose of these meetings is to collect the requirements on architecture from a maintenance perspective.
26	4	C	Collectively develop project-start architecture. Have architects and project teams together develop the project-start architecture, which is architecture focused on the situation of a specific project.
27	5	A	Formulate policy for as-is state. Develop a vision about the future of the current state of processes, organisational structures, information, applications and technical infrastructure. Based on this vision, formulate concrete guidelines on how to proceed. These guidelines indicate the conditions under which parts of the current state should be replaced or updated.
28	5	B	Draft a roadmap. Sketch the roadmap of migrating from the as-is to the to-be state based on architecture. Use these roadmaps to initiate projects and to provide guidelines to projects.
29	5	B	Set up asset management. Map out the entire set of IT assets (applications and technical infrastructure) and subject it to asset management. Take such matters into account as the functional and technical value of applications, life-cycle management, costs and use. The objective of asset management is to enable well-considered IT investment decisions.
30	5	B	Make heat maps. Assess how well processes, data and applications support the business functions and map this onto so-called heat maps. Using scores or colours, a heat map indicates the degree to which a business function is satisfied with the support in several areas, varying from excellent to very bad. A heat map can also show the importance of a business function. In this way, insight is given into where change is needed most.
31	6	A	Obtain a mandate for architecture. Ask senior management to express their commitment to architectural practices and to explicitly assign the responsibility for the architecture.
32	6	A	Draw up a table of responsibilities. Construct a table of responsibilities in which architecture-related tasks are matched with the various functions in the hospital. Indicate the person responsible for each task as well as the person who performs it. For this purpose, use such techniques as RACI (Responsible, Accountable, Consulting, Informed) or RAEW (Responsibility, Authority, Expertise, Work).
33	6	B	Set up an architecture board. Create an architecture board to formally approve architectural products and to provide an escalation platform to deal with deviations from the architecture. Members of the architectural board are to be recruited from the senior management of both business and IT.
34	6	B	Appoint a process owner for architecture. Assign ownership of the architectural process. The process owner of architecture is not only responsible for the processes in which architecture is developed but also for its alignment with other processes, such as the development and maintenance processes. The process owner is responsible for the effectiveness and efficiency of the architectural processes.

35	6	C	Allocate final responsibility for architecture. Ensure that senior management is actually involved in architecture, especially on the business side. Ensure that the ultimate responsibility for the architecture is allocated to the portfolio of a business manager.
36	7	A	Make project-start architecture mandatory. The project-start architecture makes architecture accessible to projects and makes it possible to steer their content. Not a single project is begun without project-start architecture. In the project-start architecture the relation of the project to other developments is guarded.
37	7	B	Define the tasks involved in project-portfolio management. If a form of portfolio management exists, which would typically be financially oriented, introduce some architectural requirements into it. These will be specifically concerned with the coherence among projects. Collective or infrastructural elements should be included in collective projects that deliver their products to specific applications. A rudimentary form of enterprise architecture is required to give shape to such activity.
38	7	C	Implement strategic program portfolio management. Implement a process in which architects assist senior management in building a coherent package of programs, based on both the strategic objectives and the enterprise architecture.
39	8	A	Implement an Architectural Review. Schedule testing at points along the system development trajectory and test a project for compliance with architectural prescriptions. In addition to testing at the start of the project, test at other appropriate moments, like the delivery of the functional and technical design and the acceptance of the business solution. Link up with any feedback or check mechanisms that may already exist (review procedures, go/no go moments, progress reports) If there are no check mechanisms in place, an instrument such as an architecture certificate may be used.
40	8	A	Assign a project architect. Assign a project architect to each project. The project architect is the primary contact for the project regarding architectural issues.
41	8	B	Implement project assistance. Have an architect assist a project from its initiation or kick-off to its completion. The architect advises the project about architectural concerns and indicates how the project can comply with the architecture. Ultimately, the project decisions are made by the project manager and sponsor (with a mechanism to alert the project architect of risky or unintentional deviations from the architecture). Project assistance can be implemented project by project, beginning with the most strategic projects.
42	8	B	Implement a deviation registration. Maintain a general record over all projects of all deviations from the architecture. Put this deviation registration on the agenda of the architectural board regularly.
43	8	C	Embed the monitoring of architecture compliance in the project method. Make compliance with architecture a standard component of the project method. Many hospitals have a standard method, such as PRINCE2. Indicate how monitoring compliance with architecture is incorporated into the project method. Make compliance with the architecture one of the criteria for project decharge.
44	8	C	Embed the monitoring of architecture compliance in the planning and control cycle. Include architecture compliance in the review of annual plans. This can be implemented by having a representative of the architectural team participate in the yearly control review sessions of the annual plans.
45	9	A	Establish an Architectural Review procedure. Set up a review procedure to ensure that architectural products are reviewed by all the relevant stakeholders in the hospital. Using a review matrix, it is possible to establish in advance the parties who should review architectural products.
46	9	A	Formulate quality criteria. Establish a list of the most important criteria for architectural products.
47	9	B	Audit architecture. Establish the quality requirements that the architecture must satisfy (both in terms of its process and content). Have audits regularly conducted in order to ascertain whether these requirements have been satisfied.
48	9	C	Include architectural processes in the quality system. Include architectural processes in the hospital's overall quality system. If there is no overall quality system, the architecture process can perhaps be used as a pilot to set up such a system. The objective of the quality system is to structurally evaluate and improve the architectural process.
49	10	A	Conduct an assessment. Conduct an assessment of the current state of affairs in the architectural process. The Architecture Maturity Matrix can be used for this purpose.
50	10	A	Describe the architectural processes. Describe the architectural processes, such as the establishment and maintenance of architecture, the formalization of architectural products, the role of architecture in projects and maintenance, and the role of architecture in the pre-project phase. Communicate this.
51	10	B	Establish a maintenance procedure for the architectural process. Establish procedures to deal with changes to the architectural process. The aim of these is to actively maintain the architectural process and to keep it up to date.
52	10	C	Implement assessment and improvement cycle. Establish a system in which assessments of the architectural process are regularly made. Ensure that the resulting proposals for improvement, along with any other suggestions for improvement that may occasionally arise, are evaluated according to a standard procedure and result in the necessary changes to the architectural process. Publish, communicate and implement these modifications.
53	11	A	Update the architecture. Examine the existing architectures. Are the principles and models still valid? Are there any inconsistencies? In making these evaluations, constantly ask whether the

			architecture continues to serve the current business goals. Eliminate any elements that have become outdated or redundant, and adjust the architecture to meet current requirements.
54	11	B	Establish a maintenance procedure for architectural products. Establish procedures for making changes to architecture (change management), for including architectural artifacts in the total architectural package and for maintaining the consistency of this totality. The aim is to actively maintain the architecture as a whole and to keep it up to date.
55	11	C	Develop a maintenance policy. Formulate a policy indicating how the maintenance of the various architectures is to be handled. This can, for example, indicate the architectures that are actively maintained, the times when such maintenance occurs and the individual(s) who perform(s) it.
56	12	A	Bring architecture to the attention of management. Discuss with management the value that architecture adds to the hospital. Make this value as specific as possible. Ask management to widely acknowledge architecture's value in both words and actions.
57	12	A	Obtain a budget. Make a budget available for architectural work. This can be done by explicitly including the role of architecture in annual plans or budget proposals or by earmarking time and/or money for it.
58	12	B	Have management make the case for architecture. Together with management, evaluate the value added by architecture and commit managers to the open support of it.
59	12	B	Include compliance with architecture in the project assignment. Make compliance with architecture a standard component of the project assignment. While the project method describes how a project is executed, the project assignment indicates what the results of the project are to be.
60	12	C	Involve the hospital in the improvement trajectory. Do not undertake a series of improvements on your own but involve the rest of the hospital in the process. Make clear that architecture can only add value if it is a shared responsibility.
61	13	A	Set up an architect team. Assign a number of employees the role of architect, whether or not on a full-time basis. Adopt a principle requiring part-time architects to spend a minimum of 16 hours a week on architectural activities. If desired, the architects can be coached by experienced architects from outside the hospital, either individually or in group training sessions.
62	13	A	Practice the elevator pitch. Train the architects in effective communication. Coach the architects in thinking outside in and translate this to their way of communicating.
63	13	B	Provide coaching. If necessary, provide coaching for the architects by experienced architects from outside. Make sure sufficient attention is paid to soft skills.
64	13	B	Clarify the role of the architect. Make the architect's tasks and responsibilities explicit and ensure that this role is approved at the management level. Often it is not clear to the hospital what to expect from the architects. Also, the ideas of the architects may differ from the expectations of the hospital. This kind of situation may easily lead to disappointment and ineffectiveness.
65	13	B	Draft a service catalogue. To make the added value of the architect team clear to the hospital and to indicate the services that architects provide to the hospital, compile a service catalogue for the team.
66	13	C	Professionalize the role of the architect. Create an environment that nurtures and promotes professionalism. Architects have the resources that they need, the exchange of best practices is facilitated and training or coaching is provided. In short, architecture is looked upon as a discipline that is worthy of attention and further development.
67	13	D	Remunerate the architect and recognize the role of the architect. Provide architects with a career path and give them the opportunity to distinguish themselves. Enable them to become certified and to make a career of architecture (with appropriate remuneration). Facilitate their ongoing education.
68	14	A	Establish a method in an architectural Project Plan. Define the method for developing architecture in an architectural Project Plan. The method describes the results that will be delivered and the activities required for this purpose. Describe the results as accurately as possible. Make distinctions among the various aspects (for example: processes, data, applications), forms (principle, policy directives, models) and/or perspectives (enterprise architecture, domain architecture, project-start architecture).
69	14	A	Facilitate knowledge exchange. Provide facilities for the architects to exchange knowledge, for instance by making it possible to access each others results and by providing opportunities for interaction. Build an architectural community.
70	14	B	Implement an architectural method. Implement an hospital-wide architectural method. This means that agreements are reached on the ways of differentiating architectures, the manner in which architectures are documented and how they are developed. The architects can opt for a standard modelling language or they can establish their own conventions based on proven examples.
71	14	C	Integrate the architectural method. Ensure that the architectural method adopted is not isolated, but is embedded in the change processes of the hospital. Align with existing conventions, make use of existing deliverables and milestones.
72	15	A	Organise interaction. Stimulate the architects to make use of each others knowledge and experience. One way to stimulate this, is to have them participate in differing teams with specific objectives. Another way is to institute a periodic (weekly or biweekly) architect meeting. Following courses together can also create unity.

73	15	A	Shared responsibility. Make the architects responsible for the whole architecture. Do not allow architects to distance themselves from parts of the architecture because they are outside their personal scope. Ensure that the architects act as one for the outside world.
74	15	B	Conduct a Stakeholder Inventory. Identify the stakeholders of architecture, what their interests are, what roles they play insofar as architecture is concerned and how they can be involved. This inventory can be used to determine the appropriate manner of interaction and collaboration with stakeholders.
75	15	B	Draw up a Communication Matrix. Construct a Communication Matrix in which a record of communication with each target group (group of stakeholders or interested parties) is kept, indicating what architectural topic is to be discussed, when, how and by whom. In this way, the Communication Matrix constitutes an instrument in which all communications concerning architecture are planned and monitored. In planning communication activities, it is extremely important to have a clear idea about what the objective is. In addition, the timing of the actions is important. Waiting too long before communicating to stakeholders leads to an ivory-tower situation. Communicating too soon creates the risk that expectations may be aroused that cannot soon be fulfilled.
76	15	B	Establish an architectural community. Establish a community in which architects and stakeholders talk about issues in an informal manner. The aim of the architectural community is to involve people in the hospital with architecture and, at the same time, to create a sounding board for the architects. The issues can involve both the content and the process of architecture.
77	15	C	Set up an architectural platform. Set up an architectural platform in which architects and stakeholders can come together and, in a formal manner, discuss issues and make decisions. The most important stakeholders are business managers, project managers and IT management (system maintenance and development). The issues can involve both the content and the process of architecture. If necessary, work groups can be instructed to research and elaborate certain elements.
78	16	A	Run a pilot using an architectural tool. Undertake a pilot project using a tool to support the development and maintenance of architectures. Use the pilot project to acquire experience with the tool and to determine the usefulness of a tool.
79	16	B	Implement architectural tool. Select the architectural tool that best supports the architect's work and implement it hospital-wide in such a manner that the use of the tool is integrated into the hospital's architectural process.
80	16	C	Implement an integrated toolkit. Implement an integrated toolkit that not only develops various architectures but also ensures consistency between architectures, by integrating the various tools. An alternative is one tool that covers all parts of the architecture.
81	17	A	Make plans for architectural projects. Formulate a plan for architectural development projects. This plan at least includes an estimate of the project duration, the human and other resources required, and time frames for the completion of project components and milestones.
82	17	B	Implement a planning method. Implement an hospital-wide planning method. This means that a plan is always formulated for architectural projects in accordance with a prescribed set of standard activities, rules and guidelines for budgeting and planning.
83	17	C	Evaluate architectural plans. Collect data on planning and execution of previous architectural projects and use these empirical figures to professionalize the planning process.

Appendix D: Checkpoints from the enterprise architecture maturity model for hospitals

Table 82: Checkpoints from the enterprise architecture maturity model for hospitals per focus area and maturity level

#	Focus Area	Level	Checkpoints
1	1	A	An architectural document will only be drafted if there is someone in need of the result
2	1	A	Prior to developing the architectural models and principles, it is determined who will be using the result
3	1	A	The architecture addresses issues that are relevant to the hospital
4	1	A	Reference architectures are used as inspiration when making new architectural products
5	1	B	All relevant parties are involved in the development of the architectural models and principles (e.g. business managers, administrators, developers, line staff)
6	1	B	The architecture shows how the stakeholders' interests have been addressed
7	1	B	The non-functional requirements are adequately incorporated in the architectural models and principles
8	1	B	A distinction is made between enterprise architecture and project architecture
9	1	C	The cohesion between the different architectural deliverables is effectively safeguarded during the development of the architecture
10	1	C	An effective form of requirement management is in place for all constituent architectures relevant to the hospital
11	1	C	The architecture covers the relevant segments of the hospital (i.e. those segments for which it is desirable to have direction)
12	1	C	The enterprise architecture and project architectures are consistent with each other
13	2	A	The architecture is acknowledged by management.
14	2	A	The architecture offers a clear picture of what the hospital wants.
15	2	A	The architecture can be accessed by all employees.
16	2	B	The architecture is used to give direction to business and IT developments
17	2	B	The architecture provides guidelines at the correct level that can be followed during a project's execution
18	2	B	The architecture has a clear status
19	2	C	Architecture plays an integral role in the hospital’s decision-making process
20	2	C	The vision that serves as the basis for the architecture is shared by general management
21	2	C	The ownership of processes, data and information systems has been effectively arranged
22	3	A	The relationship between the architectural choices and the hospital’s business objectives is clear
23	3	A	The architectural choices are in line with the business strategy and objectives
24	3	B	Architects and business representatives do not hesitate to get in touch with one another
25	3	B	Concrete business objectives form the immediate cause for the development of the architectural models and principles
26	3	B	When developing architectural models and principles, it is clear to what business objectives the architecture needs to contribute
27	3	C	If the business intends to make changes, it automatically involves architects as a partner in the discussion.
28	3	C	When giving shape to changes, the business feels supported by the architects.
29	3	C	The architects proactively bring relevant trends and developments in the market to the attention of business management.
30	4	A	There are projects that take the architecture into account.
31	4	A	Staff working on projects occasionally ask questions about the architecture.
32	4	A	Architects are occasionally involved in design and construction.
33	4	B	Architecture has a place within the standard development process
34	4	B	The architects pay specific attention to the architecture’s practical value for projects.

35	4	B	The architecture is taken into account when making changes (maintenance).
36	4	C	The architectural process is regularly provided with feedback by the development process.
37	4	C	The architects help the developers to tailor the general architectural principles to their specific situation.
38	4	C	The architectural process is regularly provided with feedback by the maintenance function.
39	5	A	The architecture pays attention to the current situation (existing processes, organisational structure, information systems and technical infrastructure).
40	5	A	Policy has been formulated with regard to the current situation (existing processes, organisational structure, information systems and technical infrastructure).
41	5	A	Guidelines have been formulated for the maintenance of systems that do not meet the requirements of the target architecture.
42	5	B	The architecture indicates the relationship between the existing situation and the desired situation.
43	5	B	The architecture offers guidelines in the area of migration (how to proceed from an existing to a desired situation).
44	5	B	The architecture clearly distinguishes between different planning horizons.
45	5	B	There is an up-to-date description of the current situation (existing processes, organisational structure, information systems and technical infrastructure).
46	6	A	The responsibility for the content of the architecture as a whole has been explicitly assigned to someone in the hospital.
47	6	A	Each architectural product has an owner (responsible for the content).
48	6	A	The content of the architecture has an official status within the hospital.
49	6	B	The hospital has a body where decisions relating to the architecture can be taken (an architecture board, for instance).
50	6	B	The responsibility for the architectural process as a whole has been explicitly assigned to someone in the hospital.
51	6	C	Architecture is included in the portfolio of one of the members of the senior management team.
52	6	C	Architecture is also the responsibility of business management.
53	6	C	The manager responsible for architecture is held accountable for the extent to which architecture contributes to the business objectives.
54	7	A	The architecture is used as a guideline within individual projects for making design choices that are in line with the other developments within the hospital.
55	7	A	Architecture is used to prevent projects from carrying out work that has already been done.
56	7	A	Before a project is started up, it is first checked how it will fit within existing and planned developments.
57	7	B	The architecture is used to realise integral coordination between all current and scheduled projects.
58	7	B	The architecture is used to distribute development activities among the projects.
59	7	C	The architects are involved in the building of a change portfolio on the basis of the strategic objectives.
60	8	A	Whether projects take the architecture into account is noticed
61	8	A	Deviations from the architecture are recorded.
62	8	B	Mechanisms are in place to stimulate compliance with the architecture (e.g. as part of the project management method or by way of formal reviews)
63	8	B	Actions are taken to ensure that projects satisfy the requirements of the architecture (e.g. communication sessions or trainings).
64	8	B	Deviations from the architecture are actively managed (e.g. in an architecture board).
65	8	C	Architectural compliance is part of the project assignment.
66	8	C	Architectural compliance is a matter of course in a project.
67	8	C	There are processes in place for the conscious and controlled exemption – in incidental cases – of projects from the need to comply with the architecture.
68	9	A	Attempts are made to review the architectural models and principles in some way or other with regard to quality.
69	9	A	Quality standards have been formulated for the architecture.
70	9	B	The hospital pays structural attention to the quality of the architecture.
71	9	B	The hospital has set up a quality assurance programme for the architecture.
72	9	C	The quality of the architecture is part of a general hospital-wide quality assurance policy

73	9	C	The hospital pays structural attention to the effect of the architectural practice (examining, for example, to which extent having an architectural practice contributes to the achievement of its strategic and business objectives).
74	9	C	When thinking about architecture in terms of quality, the relationship between architecture and the other processes within the hospital is taken into account (e.g. strategy formation processes, development processes and by assigning responsibility for the quality assurance to an audit service).
75	9	C	Afterwards, it is possible to determine on the basis of registrations how the assurance of the architectural quality took place.
76	10	A	The architectural process has been described
77	10	A	The hospital is acquainted with the architectural process.
78	10	A	It is occasionally checked whether the architectural process still meets the hospital's needs.
79	10	B	Management procedures have been set up for the architectural process.
80	10	B	Responsibility for the management of the architectural process has been assigned within the hospital.
81	10	B	Changes in the architectural process are immediately communicated to the relevant stakeholders.
82	10	C	The architectural process is evaluated according to a regular cycle.
83	10	C	A mechanism has been introduced for the submission of improvement proposals for the architectural process.
84	10	C	Improvement proposals regularly result in actual modifications to the architectural process.
85	11	A	It is occasionally checked whether the architecture is still up to date.
86	11	A	Outdated components are removed from the architecture.
87	11	A	A new version of the architecture is published from time to time.
88	11	B	A management procedure has been formulated for architectural products
89	11	B	The hospital has a procedure for dealing with change proposals for architectural products.
90	11	B	Management of the architectural products has been included in the architect's job responsibilities.
91	11	B	Changes to the architecture are immediately communicated to all relevant stakeholders.
92	11	C	There is policy in place outlining the management of the architecture
93	11	C	The hospital differentiates between how different components of the architecture are managed.
94	11	C	There is a policy in place about embedding reference architectures in the architectural products of the hospital
95	12	A	Architecture is viewed as an important issue by the IT management.
96	12	A	Budget and time are structurally allocated to architecture.
97	12	B	Business and IT management promote architecture as an inextricable component of business and IT projects
98	12	B	Management bases its policies on time, money and quality considerations, in which compliance with architectural requirements is viewed as an essential aspect of quality.
99	12	C	Architects are supported by management in the ongoing improvement of the architectural process.
100	12	C	Architecture is viewed by general management as a strategic issue.
101	13	A	The role of architect exists within the hospital.
102	13	A	The architects can explain the architecture's added value for the hospital.
103	13	B	The architects's tasks and responsibilities have been laid down.
104	13	B	The architects have the required knowledge.
105	13	B	The architects have the required skills.
106	13	C	The architect is supported with methods and tools.
107	13	C	Training programmes have been defined for the architects.
108	13	C	The exchange of best practices is supported.
109	13	D	The hospital has an educational plan for architects.
110	13	D	The hospital has a career path for architects.
111	14	A	The architects have adopted certain conventions for describing architecture.
112	14	A	The architects have a good idea of which components the architecture should contain.
113	14	A	The architects are familiar with relevant best-practices in healthcare (e.g. the ZiRA)

114	14	B	There is a shared architectural method within the hospital.
115	14	B	The basic ideas of the prescribed architectural method are adhered to when developing architectural models and principles.
116	14	B	During the development of architectural models and principles, possible deviations from the prescribed architectural method are substantiated and documented.
117	14	B	For every architectural product, a deliberate choice has been made to link it to a best-practice or not.
118	14	C	The architectural method distinguishes a variety of perspectives for describing the architecture to different stakeholders.
119	14	C	The architectural method establishes a relationship between the architecture and the organisation's change processes.
120	15	A	There is structural interaction between the architects.
121	15	A	The architects do not hesitate to get in touch with one another.
122	15	A	The architects share a common perspective on architecture.
123	15	A	Activities are effectively distributed among the architects.
124	15	B	The hospital's employees have a genuine interest in the architecture.
125	15	B	The architects effectively communicate with the hospital regarding relevant developments in the architectural area.
126	15	B	The architects enjoy sufficient visibility and credibility within the hospital.
127	15	C	The architectural stakeholders have the required knowledge and skills to effectively work with architecture.
128	15	C	The architectural stakeholders assume responsibility for the development and application of the architecture.
129	16	A	Architectural tools are used to record and maintain the architecture
130	16	B	All architects use the same tools
131	16	B	Responsibility for the management of the architectural tools has been explicitly assigned within the hospital.
132	16	B	The architectural tools support the architectural process.
133	16	C	The architectural tools that are used are all integrated with one another.
134	16	C	The mutual consistency of architectures can be checked with the aid of the architectural tools.
135	17	A	A plan is drawn up prior to the development of architectural models and principles.
136	17	A	The progress of an architectural development process is monitored.
137	17	B	There is a standard budgeting and planning method in place for architectural development processes.
138	17	B	During an architectural development process, deviations from the established budgeting and planning are substantiated and documented.
139	17	C	There is a structured process for collecting feedback regarding the budgeting and planning method adopted for architectural development processes.
140	17	C	Statistical data about budgets and plans that have been made for architectural development processes in the past are available.
141	18	A	Agreements on interoperability are made incidentally with involved organisations.
142	18	A	The architects from involved healthcare organisations do not hesitate to get in touch with one another
143	18	B	With some involved healthcare organisations interoperability agreements have been made on process and information level. These agreements rest on standards (i.e. HL7)
144	18	B	The architects from involved healthcare organisations effectively communicate with each other regarding relevant developments in the architectural area
145	18	C	Interoperability agreements have been made with all stakeholders in the ecosystem on process and information level. These agreements rest on standards
146	18	C	Clear agreements are made on which kind of processes and information is exchanged with stakeholders in the ecosystem
147	18	C	The architecture is set up in such a way that the hospital is able to participate in agreement systems for the healthcare domain (e.g. MedMij)
148	18	D	The architecture allows that healthcare information can be stored and exchanged based on standards
149	18	D	The architecture allows cross-sector integration on all levels (process, application, information, and infrastructure) throughout the whole ecosystem
150	18	D	The architecture of the hospital is interoperable by design

Appendix E: SFI's from the enterprise architecture maturity model for hospitals

Table 83: Suggestions for improvement from the enterprise architecture maturity model for hospitals per focus area and maturity level

#	Focus Area	Level	Suggestion for improvement
1	1	A	Arrange for a sponsor. Ensure that the primary sponsor for any architecture being developed is explicitly indicated. Take the task of finding a sponsor seriously. This means that the sponsor should be actively involved in the development of the architecture.
2	1	A	Take a goal-oriented approach to developing architecture. Establish the architectural product that is needed. Determine who wants to have this product, who will be using the product and to what end, and which aspects the product has to address to satisfy these demands. It is useful to document this in a one-page document. Discuss this with the relevant stakeholders and execute it.
3	1	B	Multidisciplinary teams. Perform the actual development of architectural principles and models within multidisciplinary teams, ensuring participation of all relevant stakeholders. Make sure the stakeholders share responsibility for the overall result.
4	1	B	Workshops. Involve busy stakeholders by inviting them to workshops. Let others (architects) do the detailed elaboration.
5	1	B	Make choices traceable. Make explicit for each architectural choice the rationale behind it and whose concern is addressed by this rationale. This can be done by including the rationale in the descriptions of the architecture principles and/or by connecting principles to each other, for instance in a chain matrix. Models must contain an explicit description of the underlying reasoning and motivation.
6	1	C	Demonstrate architectural coherence. Demonstrate the coherence between architectures by making the relationships among the various architectures in the organisation apparent. The DYA framework can be used for this purpose. By positioning all the architectures in this framework, it is possible to reveal overlap and gaps.
7	1	C	Review teams. Have architectural products reviewed by at least two architects from architectural domains that are related to the architectural domain described.
8	1	C	Manage requirements. Introduce and maintain an architecture requirements document that contains the requirements on the architecture.
9	2	A	Publish the architecture. Ensure that the existing architectures are brought to the attention of the organisation. Publish the architecture on a site that is accessible to the entire organisation. Make the site attractive and interactive, for instance in the form of a (semantic) wiki. Present the architecture as representing the vision of where the organisation ultimately wants to go.
10	2	A	Story telling. Develop an inspiring story that tells why the architecture is there and why it is as it is. In other words, the vision behind the architecture. Ensure that all architects can tell this story in an inspiring way.
11	2	B	Implement project-start architecture. Supply each project with a projectstart architecture. Project-start architectures are formulated so that they are accessible, understandable and applicable to projects. Project-start architectures also establish the frameworks that give effective direction to the decisions made in projects.
12	2	B	Versioning of architecture documents. Provide architecture documents with a number of attributes concerning versioning. In addition to the status of the document, the 'sell by' date is a useful attribute: the date until which the given status is valid. Ensure that the person who maintains the document receives a signal to renew the sell by date in time. Also provide an owner of the document.
13	2	C	Incorporate architecture into the planning and control cycle. Incorporate the role of architecture into the organisation's planning and budgeting cycle. This means that, in formulating annual plans, architectural factors are considered when projects and programs are being selected. In practice, this mostly occurs by involving a member of the architect team in planning.
14	3	A	Explain the basis of the architecture. Examine the existing architecture and relate choices and statements to the business strategy and goals (to the extent that this has not already been done). If such a relationship cannot be established, take a very critical look at the architectural principles and models. Frequently, choices and statements are made in the architecture without any reference to business goals and requirements. As a consequence, these choices are constantly being questioned.
15	3	B	Set up account management for business. Initiate dialogue with business managers and their representatives, such as the information managers of the business units. This can be done by allocating business domains to the architects. The architects build up a lasting, structural relationship with their "accounts." They come to know what is going on inside the given business domain, where the needs are and how architecture can contribute to the achievement of the business goals.
16	3	C	Involve architecture in the pre-project phase (Strategic Dialogue). To begin with, collaborate with business management to determine what the added value of architecture has to be for the organisation.

			Based on this determination, establish the added value of architecture in the business discussions leading up to the initiation of projects – in formulating the business cases, for example. This added value is mostly to be found in the rapid provision of insight concerning the consequences of choices and the manner of achieving business goals.
17	3	C	Set up issue management. Make an agreement with the business managers that the architect team will take on the task of monitoring difficult issues. This means that the architect team will prepare and coordinate the handling and resolution of these issues with business management, and incorporate the results into policy. Of course, the resolved issues are also immediately converted into architecture.
18	3	C	Thinking outside in. Train the architects to think outside in, i.e. to think from the perspective of business issues instead of from the perspective of architecture. If necessary, have the architects attend relevant business courses.
19	4	A	Discuss the role of architecture with project managers. With the project managers, discuss what the relationship is between architecture and projects, why architecture is important and what this means for project execution. For example, have an architect discuss this at a project managers' work meeting.
20	4	A	Discuss the role of architecture with maintenance. With functional/technical management, discuss what the relationship is between architecture and maintenance, why architecture is important and what this means for maintenance. For example, have an architect discuss this at a work meeting.
21	4	A	Involve design and operations. Involve design and maintenance in the architecture processes. One way to do this, is to invite senior employees to participate in an architecture community.
22	4	B	Embed architecture in the project method. Many organisations have a method for working on projects. This can be a standard method, such as PRINCE2, but it can also be the organisation's own procedure as laid out in a project manual. Give architecture a place in this procedure by literally writing it into the standard project work procedure. The role of architecture is therefore explicitly added to the project method.
23	4	B	Embed architecture in maintenance procedures. Include the role of architecture in the description of maintenance procedures. For instance, describe how and when change requests are subjected to an architecture review.
24	4	C	Set up account management for the development process. Initiate regular meetings between members of the architect team and representatives from system development. The purpose of these meetings is to ensure good collaboration between architects and projects.
25	4	C	Set up account management for maintenance. Initiate regular meetings between members of the architect team and representatives from functional/technical management. One purpose of these meetings is to collect the requirements on architecture from a maintenance perspective.
26	4	C	Collectively develop project-start architecture. Have architects and project teams together develop the project-start architecture, which is architecture focused on the situation of a specific project.
27	5	A	Formulate policy for as-is state. Develop a vision about the future of the current state of processes, organisational structures, information, applications and technical infrastructure. Based on this vision, formulate concrete guidelines on how to proceed. These guidelines indicate the conditions under which parts of the current state should be replaced or updated.
28	5	B	Draft a roadmap. Sketch the roadmap of migrating from the as-is to the to-be state based on architecture. Use these roadmaps to initiate projects and to provide guidelines to projects.
29	5	B	Set up asset management. Map out the entire set of IT assets (applications and technical infrastructure) and subject it to asset management. Take such matters into account as the functional and technical value of applications, life-cycle management, costs and use. The objective of asset management is to enable well-considered IT investment decisions.
30	5	B	Make heat maps. Assess how well processes, data and applications support the business functions and map this onto so-called heat maps. Using scores or colours, a heat map indicates the degree to which a business function is satisfied with the support in several areas, varying from excellent to very bad. A heat map can also show the importance of a business function. In this way, insight is given into where change is needed most.
31	6	A	Obtain a mandate for architecture. Ask senior management to express their commitment to architectural practices and to explicitly assign the responsibility for the architecture.
32	6	A	Draw up a table of responsibilities. Construct a table of responsibilities in which architecture-related tasks are matched with the various functions in the organisation. Indicate the person responsible for each task as well as the person who performs it. For this purpose, use such techniques as RACI (Responsible, Accountable, Consulting, Informed) or RAEW (Responsibility, Authority, Expertise, Work).
33	6	B	Set up an architecture board. Create an architecture board to formally approve architectural products and to provide an escalation platform to deal with deviations from the architecture. Members of the architectural board are to be recruited from the senior management of both business and IT.
34	6	B	Appoint a process owner for architecture. Assign ownership of the architectural process. The process owner of architecture is not only responsible for the processes in which architecture is developed but also for its alignment with other processes, such as the development and maintenance processes. The process owner is responsible for the effectiveness and efficiency of the architectural processes.

35	6	C	Allocate final responsibility for architecture. Ensure that senior management is actually involved in architecture, especially on the business side. Ensure that the ultimate responsibility for the architecture is allocated to the portfolio of a business manager.
36	7	A	Make project-start architecture mandatory. The project-start architecture makes architecture accessible to projects and makes it possible to steer their content. Not a single project is begun without project-start architecture. In the project-start architecture the relation of the project to other developments is guarded.
37	7	B	Define the tasks involved in project-portfolio management. If a form of portfolio management exists, which would typically be financially oriented, introduce some architectural requirements into it. These will be specifically concerned with the coherence among projects. Collective or infrastructural elements should be included in collective projects that deliver their products to specific applications. A rudimentary form of enterprise architecture is required to give shape to such activity.
38	7	C	Implement strategic program portfolio management. Implement a process in which architects assist senior management in building a coherent package of programs, based on both the strategic objectives and the enterprise architecture.
39	8	A	Implement an Architectural Review. Schedule testing at points along the system development trajectory and test a project for compliance with architectural prescriptions. In addition to testing at the start of the project, test at other appropriate moments, like the delivery of the functional and technical design and the acceptance of the business solution. Link up with any feedback or check mechanisms that may already exist (review procedures, go/no go moments, progress reports) If there are no check mechanisms in place, an instrument such as an architecture certificate may be used.
40	8	A	Assign a project architect. Assign a project architect to each project. The project architect is the primary contact for the project regarding architectural issues.
41	8	B	Implement project assistance. Have an architect assist a project from its initiation or kick-off to its completion. The architect advises the project about architectural concerns and indicates how the project can comply with the architecture. Ultimately, the project decisions are made by the project manager and sponsor (with a mechanism to alert the project architect of risky or unintentional deviations from the architecture). Project assistance can be implemented project by project, beginning with the most strategic projects.
42	8	B	Implement a deviation registration. Maintain a general record over all projects of all deviations from the architecture. Put this deviation registration on the agenda of the architectural board regularly.
43	8	C	Embed the monitoring of architecture compliance in the project method. Make compliance with architecture a standard component of the project method. Many organisations have a standard method, such as PRINCE2. Indicate how monitoring compliance with architecture is incorporated into the project method. Make compliance with the architecture one of the criteria for project decharge.
44	8	C	Embed the monitoring of architecture compliance in the planning and control cycle. Include architecture compliance in the review of annual plans. This can be implemented by having a representative of the architectural team participate in the yearly control review sessions of the annual plans.
45	9	A	Establish an Architectural Review procedure. Set up a review procedure to ensure that architectural products are reviewed by all the relevant stakeholders in the organisation. Using a review matrix, it is possible to establish in advance the parties who should review architectural products.
46	9	A	Formulate quality criteria. Establish a list of the most important criteria for architectural products.
47	9	B	Audit architecture. Establish the quality requirements that the architecture must satisfy (both in terms of its process and content). Have audits regularly conducted in order to ascertain whether these requirements have been satisfied.
48	9	C	Include architectural processes in the quality system. Include architectural processes in the organisation's overall quality system. If there is no overall quality system, the architecture process can perhaps be used as a pilot to set up such a system. The objective of the quality system is to structurally evaluate and improve the architectural process.
49	10	A	Conduct an assessment. Conduct an assessment of the current state of affairs in the architectural process. The Architecture Maturity Matrix can be used for this purpose.
50	10	A	Describe the architectural processes. Describe the architectural processes, such as the establishment and maintenance of architecture, the formalisation of architectural products, the role of architecture in projects and maintenance, and the role of architecture in the pre-project phase. Communicate this.
51	10	B	Establish a maintenance procedure for the architectural process. Establish procedures to deal with changes to the architectural process. The aim of these is to actively maintain the architectural process and to keep it up to date.
52	10	C	Implement assessment and improvement cycle. Establish a system in which assessments of the architectural process are regularly made. Ensure that the resulting proposals for improvement, along with any other suggestions for improvement that may occasionally arise, are evaluated according to a standard procedure and result in the necessary changes to the architectural process. Publish, communicate and implement these modifications.
53	11	A	Update the architecture. Examine the existing architectures. Are the principles and models still valid? Are there any inconsistencies? In making these evaluations, constantly ask whether the architecture

			continues to serve the current business goals. Eliminate any elements that have become outdated or redundant, and adjust the architecture to meet current requirements.
54	11	B	Establish a maintenance procedure for architectural products. Establish procedures for making changes to architecture (change management), for including architectural artifacts in the total architectural package and for maintaining the consistency of this totality. The aim is to actively maintain the architecture as a whole and to keep it up to date.
55	11	C	Develop a maintenance policy. Formulate a policy indicating how the maintenance of the various architectures is to be handled. This can, for example, indicate the architectures that are actively maintained, the times when such maintenance occurs and the individual(s) who perform(s) it.
56	12	A	Bring architecture to the attention of management. Discuss with management the value that architecture adds to the organisation. Make this value as specific as possible. Ask management to widely acknowledge architecture's value in both words and actions.
57	12	A	Obtain a budget. Make a budget available for architectural work. This can be done by explicitly including the role of architecture in annual plans or budget proposals or by earmarking time and/or money for it.
58	12	B	Have management make the case for architecture. Together with management, evaluate the value added by architecture and commit managers to the open support of it.
59	12	B	Include compliance with architecture in the project assignment. Make compliance with architecture a standard component of the project assignment. While the project method describes how a project is executed, the project assignment indicates what the results of the project are to be.
60	12	C	Involve the organisation in the improvement trajectory. Do not undertake a series of improvements on your own but involve the rest if the organisation in the process. Make clear that architecture can only add value if it is a shared responsibility.
61	13	A	Set up an architect team. Assign a number of employees the role of architect, whether or not on a full-time basis. Adopt a principle requiring part-time architects to spend a minimum of 16 hours a week on architectural activities. If desired, the architects can be coached by experienced architects from outside the organisation, either individually or in group training sessions.
62	13	A	Practice the elevator pitch. Train the architects in effective communication. Coach the architects in thinking outside in and translate this to their way of communicating.
63	13	B	Provide coaching. If necessary, provide coaching for the architects by experienced architects from outside. Make sure sufficient attention is paid to soft skills.
64	13	B	Clarify the role of the architect. Make the architect's tasks and responsibilities explicit and ensure that this role is approved at the management level. Often it is not clear to the organisation what to expect from the architects. Also, the ideas of the architects may differ from the expectations of the organisation. This kind of situation may easily lead to disappointment and ineffectiveness.
65	13	B	Draft a service catalogue. To make the added value of the architect team clear to the organisation and to indicate the services that architects provide to the organisation, compile a service catalogue for the team.
66	13	C	Professionalise the role of the architect. Create an environment that nurtures and promotes professionalism. Architects have the resources that they need, the exchange of best practices is facilitated and training or coaching is provided. In short, architecture is looked upon as a discipline that is worthy of attention and further development.
67	13	D	Remunerate the architect and recognise the role of the architect. Provide architects with a career path and give them the opportunity to distinguish themselves. Enable them to become certified and to make a career of architecture (with appropriate remuneration). Facilitate their ongoing education.
68	14	A	Establish a method in an architectural Project Plan. Define the method for developing architecture in an architectural Project Plan. The method describes the results that will be delivered and the activities required for this purpose. Describe the results as accurately as possible. Make distinctions among the various aspects (for example: processes, data, applications), forms (principle, policy directives, models) and/or perspectives (enterprise architecture, domain architecture, project-start architecture).
69	14	A	Facilitate knowledge exchange. Provide facilities for the architects to exchange knowledge, for instance by making it possible to access each others results and by providing opportunities for interaction. Build an architectural community.
70	14	A	Get acquainted with the best-practices in healthcare. Take a look at them and make sure that the architects are acquainted with them. Know which best-practices there are and what the scope of them is. Take a look at relevant best-practices for inspiration for your own architectural products
71	14	B	Implement an architectural method. Implement an organisation-wide architectural method. This means that agreements are reached on the ways of differentiating architectures, the manner in which architectures are documented and how they are developed. The architects can opt for a standard modelling language or they can establish their own conventions based on proven examples.
72	14	B	Check common ground with the best-practices. Compare the architectural products of the hospital with best-practices. Think whether it would be beneficial to make your products adhere to these best-practices.
73	14	C	Integrate the architectural method. Ensure that the architectural method adopted is not isolated, but is embedded in the change processes of the organisation. Align with existing conventions, make use of existing deliverables and milestones.

74	15	A	Organise interaction. Stimulate the architects to make use of each others knowledge and experience. One way to stimulate this, is to have them participate in differing teams with specific objectives. Another way is to institute a periodic (weekly or biweekly) architect meeting. Following courses together can also create unity.
75	15	A	Shared responsibility. Make the architects responsible for the whole architecture. Do not allow architects to distance themselves from parts of the architecture because they are outside their personal scope. Ensure that the architects act as one for the outside world.
76	15	B	Conduct a Stakeholder Inventory. Identify the stakeholders of architecture, what their interests are, what roles they play insofar as architecture is concerned and how they can be involved. This inventory can be used to determine the appropriate manner of interaction and collaboration with stakeholders.
77	15	B	Draw up a Communication Matrix. Construct a Communication Matrix in which a record of communication with each target group (group of stakeholders or interested parties) is kept, indicating what architectural topic is to be discussed, when, how and by whom. In this way, the Communication Matrix constitutes an instrument in which all communications concerning architecture are planned and monitored. In planning communication activities, it is extremely important to have a clear idea about what the objective is. In addition, the timing of the actions is important. Waiting too long before communicating to stakeholders leads to an ivory-tower situation. Communicating too soon creates the risk that expectations may be aroused that cannot soon be fulfilled.
78	15	B	Establish an architectural community. Establish a community in which architects and stakeholders talk about issues in an informal manner. The aim of the architectural community is to involve people in the organisation with architecture and, at the same time, to create a sounding board for the architects. The issues can involve both the content and the process of architecture.
79	15	C	Set up an architectural platform. Set up an architectural platform in which architects and stakeholders can come together and, in a formal manner, discuss issues and make decisions. The most important stakeholders are business managers, project managers and IT management (system maintenance and development). The issues can involve both the content and the process of architecture. If necessary, work groups can be instructed to research and elaborate certain elements.
80	16	A	Run a pilot using an architectural tool. Undertake a pilot project using a tool to support the development and maintenance of architectures. Use the pilot project to acquire experience with the tool and to determine the usefulness of a tool.
81	16	B	Implement architectural tool. Select the architectural tool that best supports the architect's work and implement it organisation-wide in such a manner that the use of the tool is integrated into the organisation's architectural process.
82	16	C	Implement an integrated toolkit. Implement an integrated toolkit that not only develops various architectures but also ensures consistency between architectures, by integrating the various tools. An alternative is one tool that covers all parts of the architecture.
83	17	A	Make plans for architectural projects. Formulate a plan for architectural development projects. This plan at least includes an estimate of the project duration, the human and other resources required, and time frames for the completion of project components and milestones.
84	17	B	Implement a planning method. Implement an organisation-wide planning method. This means that a plan is always formulated for architectural projects in accordance with a prescribed set of standard activities, rules and guidelines for budgeting and planning.
85	17	C	Evaluate architectural plans. Collect data on planning and execution of previous architectural projects and use these empirical figures to professionalise the planning process.
86	18	A	Organise interaction. Make sure that you come in contact with architects from other healthcare organisations. Get in contact with these architects and make arrangements about information exchange.
87	18	B	Make arrangement about standards. Internally and externally, arrangement should be made about which information is exchanged. Make sure that you make these arrangements are based on established standards
88	18	C	Expand collaboration. Build on the arrangement already made with the healthcare organisations and expand to all stakeholders in the ecosystem. Make sure that the information exchanged with them is based on established standards. Get involved in a community of architecture in healthcare and make sure that relevant developments are on the agenda.
89	18	D	Make architecture integral. From design the architecture should be interoperable on all levels. Get in contact with the stakeholders in the ecoystem and make arrangements to integrate on all levels. It is important that everyone in the ecosystem supports this.

Appendix F: SPSS output

Case Processing Summary

		N	%
Cases	Valid	26	100,0
	Excluded[a]	0	,0
	Total	26	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
,807	2

Figure 40: SPSS output - Cronbach's Alpha of 'Intention to use'

Case Processing Summary

		N	%
Cases	Valid	26	100,0
	Excluded[a]	0	,0
	Total	26	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
,803	4

Figure 41: SPSS output - Cronbach's Alpha of 'Perceived usefulness'

Case Processing Summary

		N	%
Cases	Valid	26	100,0
	Excluded[a]	0	,0
	Total	26	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
,748	4

Figure 42: SPSS output - Cronbach's Alpha of 'Perceived ease of use'

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ITU1	26	3	7	5,69	,884
ITU2	26	1	7	5,27	1,218
PU1	26	2	7	4,81	1,059
PU2	26	2	6	4,12	1,107
PU3	26	2	7	4,85	1,156
PU4	26	2	7	5,35	1,018
PEOU1	26	1	7	5,00	1,386
PEOU2	26	2	7	4,77	1,608
PEOU3	26	1	7	4,69	1,490
PEOU4	26	1	6	4,08	1,164
Valid N (listwise)	26				

Figure 43: Descriptive statistics on all statements of the TAM survey

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ITUavg	26	3,0	7,0	5,481	,9745
PUavg	26	2,00	6,50	4,7788	,86118
PEOUavg	26	2,00	6,25	4,6338	1,07172
Valid N (listwise)	26				

Figure 44: Descriptive statistics on the TAM variables

Appendix G: Final maturity profiles of the hospitals (in Dutch)

Aandachtsgebieden	Schaal												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Opstellen van architectuur		A			B			C					
Gebruik van architectuur			A			B				C			
Aansluiting op business-strategie		A			B					C			
Aansluiting op realisatie			A				B			C			
Relatie met bestaande situatie					A				B				
Verantwoordelijkheden en bevoegdheden				A		B					C		
Aansluiting op veranderportfolio				A				B		C			
Bewaking				A		B		C					
Kwaliteitsborging								A		B		C	
Beheer architectuurproces							A		B		C		
Beheer architectuurproducten					A			B					C
Commitment en motivatie		A					B		C				
Invulling architectuurrol				A		B		C				D	
Architectuurmethode				A					B			C	
Interactie en samenwerking			A		B				C				
Architectuurtools							A				B		C
Begroting en planning					A						B		C
Interoperabiliteit			A			B			C			D	

Figure 45: Final maturity profile hospital A

Aandachtsgebieden	Schaal												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Opstellen van architectuur		A			B			C					
Gebruik van architectuur			A			B				C			
Aansluiting op business-strategie		A			B					C			
Aansluiting op realisatie			A				B			C			
Relatie met bestaande situatie					A				B				
Verantwoordelijkheden en bevoegdheden				A		B					C		
Aansluiting op veranderportfolio				A				B		C			
Bewaking				A		B		C					
Kwaliteitsborging								A		B		C	
Beheer architectuurproces							A		B		C		
Beheer architectuurproducten					A			B					C
Commitment en motivatie		A					B		C				
Invulling architectuurrol				A		B		C				D	
Architectuurmethode				A					B			C	
Interactie en samenwerking			A		B				C				
Architectuurtools							A				B		C
Begroting en planning					A						B		C
Interoperabiliteit			A			B			C			D	

Figure 46: Final maturity profile hospital B

Aandachtsgebieden	Schaal												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Opstellen van architectuur		A			B			C					
Gebruik van architectuur			A			B				C			
Aansluiting op business-strategie		A			B					C			
Aansluiting op realisatie			A				B			C			
Relatie met bestaande situatie					A				B				
Verantwoordelijkheden en bevoegdheden				A		B					C		
Aansluiting op veranderportfolio				A				B		C			
Bewaking				A		B		C					
Kwaliteitsborging								A		B		C	
Beheer architectuurproces							A		B		C		
Beheer architectuurproducten					A			B					C
Commitment en motivatie		A					B		C				
Invulling architectuurrol				A		B		C				D	
Architectuurmethode				A					B			C	
Interactie en samenwerking			A		B				C				
Architectuurtools							A				B		C
Begroting en planning					A						B		C
Interoperabiliteit			A			B			C			D	

Figure 47: Final maturity profile of hospital C

Aandachtsgebieden	Schaal												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Opstellen van architectuur		A			B			C					
Gebruik van architectuur			A			B				C			
Aansluiting op ziekenhuis-strategie		A			B					C			
Aansluiting op realisatie			A				B			C			
Relatie met bestaande situatie					A				B				
Verantwoordelijkheden en bevoegdheden				A		B					C		
Aansluiting op veranderportfolio				A				B		C			
Bewaking				A		B		C					
Kwaliteitsborging								A		B		C	
Beheer architectuurproces							A		B		C		
Beheer architectuurproducten					A			B					C
Commitment en motivatie		A					B		C				
Invulling architectuurrol				A		B		C				D	
Architectuurmethode				A					B			C	
Interactie en samenwerking			A		B				C				
Architectuurtools							A				B		C
Begroting en planning					A						B		C
Interoperabiliteit			A			B			C			D	

Figure 48: Final maturity profile hospital D

Aandachtsgebieden	Schaal												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Opstellen van architectuur		A			B			C					
Gebruik van architectuur			A			B				C			
Aansluiting op ziekenhuis-strategie		A			B					C			
Aansluiting op realisatie			A				B			C			
Relatie met bestaande situatie					A				B				
Verantwoordelijkheden en bevoegdheden				A		B					C		
Aansluiting op veranderportfolio				A				B		C			
Bewaking				A		B		C					
Kwaliteitsborging								A		B		C	
Beheer architectuurproces							A		B		C		
Beheer architectuurproducten					A			B					C
Commitment en motivatie		A					B		C				
Invulling architectuurrol				A		B		C				D	
Architectuurmethode				A					B			C	
Interactie en samenwerking			A		B				C				
Architectuurtools							A				B		C
Begroting en planning					A						B		C
Interoperabiliteit			A			B			C			D	

Figure 49: Final maturity profile of hospital E

Aandachtsgebieden	Schaal												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Opstellen van architectuur		A			B			C					
Gebruik van architectuur			A			B				C			
Aansluiting op ziekenhuis-strategie		A			B					C			
Aansluiting op realisatie			A				B			C			
Relatie met bestaande situatie					A				B				
Verantwoordelijkheden en bevoegdheden				A		B					C		
Aansluiting op veranderportfolio				A				B		C			
Bewaking				A		B		C					
Kwaliteitsborging								A		B		C	
Beheer architectuurproces							A		B		C		
Beheer architectuurproducten					A			B					C
Commitment en motivatie		A					B		C				
Invulling architectuurrol				A		B		C				D	
Architectuurmethode				A					B			C	
Interactie en samenwerking			A		B				C				
Architectuurtools							A				B		C
Begroting en planning					A						B		C
Interoperabiliteit			A			B			C			D	

Figure 50: Final maturity profile of hospital F

Appendix H: Scientific research paper

This work was originally published as: van Zwienen M., Ruiz M., van Steenbergen M., Burriel V. (2019) A Process for Tailoring Domain-Specific Enterprise Architecture Maturity Models. In: Reinhartz-Berger I., Zdravkovic J., Gulden J., Schmidt R. (eds) Enterprise, Business-Process and Information Systems Modeling. BPMDS 2019, EMMSAD 2019. Lecture Notes in Business Information Processing, vol 352. Springer, Cham.

DOI: https://doi.org/10.1007/978-3-030-20618-5_14

The paper starts on the next page. The page numbers are original and do not correspond with the page numbers of the thesis.

A Process for Tailoring Domain-Specific Enterprise Architecture Maturity Models

Mart van Zwienen[1], Marcela Ruiz[1(✉)], Marlies van Steenbergen[2], and Verónica Burriel[1]

[1] Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands
{m.a.vanzwienen, m.ruiz, v.burriel}@uu.nl
[2] HU University of Applied Sciences,
Padualaan 99, 3584 CH Utrecht, The Netherlands
marlies.vansteenbergen@hu.nl

Abstract. Reference architectures provide strong foundations for the implementation and development of enterprise architecture. It is common for enterprise architects to encounter the challenge of managing an increasingly complex architecture. This management can be enhanced by the application of domain-independent maturity models. Nevertheless, existing maturity models do not provide enterprise architects with metrics and domain-specific solutions to ensure a successful evolution path. This research in progress presents a process for tailoring domain-specific enterprise architecture maturity models. As a proof of concept, we chose the domain of hospitals because of the following reasons: wide variety of interdependencies and many medical disciplines with their own processes, technology, and data requirements; there is no specific maturity model for the enterprise architecture of hospitals; and there are many restrictions (e.g. governmental laws) for the medical domain which are expressed in a reference enterprise architecture. We follow a design science approach from the problem investigation to the treatment design. We conclude this paper with the results of the initial validation that has been conducted with architects from the healthcare domain.

Keywords: Enterprise architecture · Maturity models · Reference architecture · Metamodeling · Tailoring process

1 Introduction

Enterprise architecture (EA) is 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 infrastructures [1]. EA ensures agility, consistency, compliance and efficiency for increasingly complex organizations [2]. Several maturity models and frameworks have been proposed to guide organizations to a more mature EA function [3]. In this context, more mature means better equipped to fulfill its purpose, possibly and hopefully leading to more effectivity [4].

The healthcare domain is characterized by a high level of complexity that stems from a variety of interdependencies and the presence of many medical disciplines with their own processes, technology, and data requirements [5]. It is difficult to cope with

I. Reinhartz-Berger et al. (Eds.): BPMDS 2019/EMMSAD 2019, LNBIP 352, pp. 196–211, 2019.
https://doi.org/10.1007/978-3-030-20618-5_14

this complexity, which is illustrated by the fact that healthcare organizations lag behind other organizations in utilizing IT [6].

Several IT maturity models are tailored to healthcare, showing that the complexity of this highly specialized domain calls for tailored maturity models [7]. However, there is not yet an enterprise architecture maturity model tailored to healthcare.

Another relevant instrument, next to maturity models, to improve the quality of the EA is a reference EA. "A reference EA is a generic EA for a class of enterprises, that is a coherent whole of EA design principles, methods and models which are used as foundation in the design and realization of the concrete EA that consists of three coherent partial architectures: the business architecture, the application architecture and the technology architecture" [8]. Ten Harmsen van der Beek, Trienekes, & Grefen [8] conclude that reference architectures can give support in coping with complexity and are the next step in maturing EA.

The aim of this research is to provide a process to tailor an EA maturity model towards a specific domain with the help of a reference EA. As proof of concept we take the healthcare domain. The scientific contribution herein is two-fold. Firstly, the main artefact of this paper is a process for tailoring an EA maturity model to a specific domain, which can be applied to other domains than healthcare as well. Secondly, the initially validated EA maturity model tailored towards hospitals itself is a contribution to healthcare maturity models.

The paper proceeds in the next section with the research design. Section 3 describes the literature review serving as background for the remainder of the paper. In Sects. 4 and 5 the tailoring process, model, and validation are presented. Finally, conclusions are presented in Sect. 6.

2 Research Design

For the development of the tailoring process, we conducted a design science project according to protocols prescribed by Wieringa [9]. Within design science, the design cycle provides a logical structure of tasks to design an artefact. These tasks are: (1) Problem investigation, (2) Treatment design and (3) Treatment validation. Figure 1 shows the implementation of the design cycle for this research in progress.

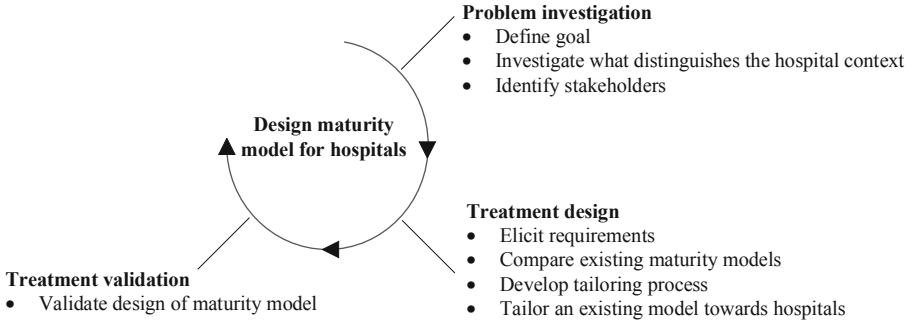

Fig. 1. Design cycle for this research in progress

Part of the goal of this research is to develop the tailoring process for the design of a maturity model for hospitals. The stakeholders are identified during the problem investigation. These stakeholders are also the experts in the semi-structured interviews for eliciting requirements during the treatment design. To tailor an existing EA maturity model towards a specific domain, first, a systematic literature review is performed to find the best fitting existing EA maturity model. The tailoring process is then developed and applied to make the model specific for the healthcare domain.

For the systematic literature review, a method is constructed by adapting the best practices from [10–12]. This resulted in the following steps: (1) define search criteria, (2) identify relevant literature, (3) backward snowballing, (4) forward snowballing and (5) synthesize data. The systematic literature review itself is presented in Sect. 3.

The treatment design step consisted of tailoring an existing maturity model. We constructed a process for integrating a reference EA in an EA maturity model and applied it. This is elaborated in Sect. 4.

To initially validate the tailoring of the EA maturity model, a focus group session is conducted. The session follows the protocol defined in [13]. The key design concepts and the execution of the focus group session are presented in Sect. 5.

3 Theoretical Background

The founder of the maturity approach in the information systems field is considered to be Richard Nolan, who was the first to propose a maturity model in 1973 [14]. In 2002, the Capability Maturity Model was published, which is recognized as a standard maturity model and provides a foundation on which a majority of the maturity models are based [3, 15]. Ross [16] introduced an architecture maturity model in 2003. Her four-stage model became a well-known EA maturity model.

To find a suitable EA maturity model as input for the tailoring, a systematic literature review is performed. Some literature reviews on EA maturity models already exist. In [3] and [17] relevant analyses of EA maturity models are shown, but do not provide a systematic approach. A more recent review from [18] is systematic but not exhaustive on maturity models, since their scope is 'post-implementation evaluation models of enterprise architecture artefacts'. In [19] the authors performed the most recent systematic review on EA maturity models but did not perform it exhaustively. They limited their search to models that are published by well-known private or public organizations. Therefore, a new exhaustive systematic literature review on EA maturity models is performed.

Firstly, the search criteria were defined. The following web platforms of scientific literature were used: (1) AIS Electronic Library, (2) IEEE Xplore Digital Library, (3) Springer Link, (4) SCOPUS and (5) ISI Web of Knowledge. On these platforms, the following search queries were conducted: (1) "enterprise architecture maturity" AND "model", (2) "enterprise architecture maturity" AND "framework", (3) "enterprise architecture maturity" AND "stages" and (4) "enterprise architecture maturity" AND "growth". Papers to which the researchers had no access, were written in a different language than English, or papers that were already derived from an earlier platform or search query were excluded. This resulted in a longlist of 75 papers.

Secondly, relevant literature was identified. For this step we used the following inclusion criteria on the 75 papers: (1) the paper introduces a new EA maturity model, (2) the paper applies an EA maturity model or (3) the paper reviews one or more EA maturity model(s). This resulted in a shortlist of 22 papers.

Thirdly, backward snowballing was performed on the shortlist. By scanning the references of the papers on the shortlist, 11 new relevant papers were identified. The inclusion criterium was that the paper should introduce an EA maturity model. 7 of the 11 papers were white-papers and were therefore not found on the scientific platforms. The other 4 did not surface because they have no mention of EA maturity in their papers. But since at least one of the 22 papers claim that these are EA maturity models, and for the sake of completeness, we included them as well.

Fourthly, forward snowballing was performed. This was only performed on papers that introduce a new EA maturity model, since we want to know whether other new EA maturity models are based on these. We used Google Scholar for the forward snowballing. Whenever a model was cited more than 100 times, the search string "enterprise architecture maturity" was initiated within these results. From the 279 papers identified through the forward snowballing, none was relevant in the context of EA maturity models that was not already identified earlier in the review, making the review exhaustive.

Finally, the data was synthesized. For this, we adapted the criteria from [3]. The key characteristics and relevant attributes for analyzing the EA maturity models are: (1) the assessment target, (2) number of maturity levels, (3) type of model and (4) type of assessment method. The assessment target can be product-oriented or process-oriented, where product-oriented models focus on products of the enterprise architecture, and process-oriented models focus on processes involved in and around enterprise architecture [3, 20]. Models are of different types: a model can be staged, continuous, or focus area oriented [20]. A staged model has a fixed number, usually 5, of maturity levels with focus areas assigned to each maturity level. Whereas within a continuous model, the same, usually 5, maturity levels are distinguished within each focus area. The focus area oriented model usually has more overall maturity levels and each focus area has its own number of specific maturity levels. Table 1 presents a comparison of the 17 identified EA maturity models.

Earlier reviews have claimed that certain models are suitable for certain purposes. In [3] was discovered that the IT Capability Maturity Framework is capable of serving as an overarching IT maturity model. The review in [17] concluded that the Dynamic Architecture Maturity Matrix (DyAMM) is the most suitable for evaluating EA.

In literature, there are also arguments on why fixed-level maturity models like the staged and continuous models have their limitations. They are not geared to show interdependence between the processes that make up the maturity levels, leading to little guidance in increasing the maturity level [4]. On the other hand, focus area oriented models allow for a finer granularity, also in the improvement measures. These models provide better step by step guidance for improvement [20]. Also, departing from 5 fixed maturity levels makes the model more flexible in defining both focus areas and interdependencies.

Table 1. Comparison between EA maturity models

Model	Assessment target	Nr. of levels	Type of model	Type of method
Maturity Model for Effective Enterprise Architecture [21]	Product-oriented	4	Staged	None explicitly mentioned
Maturity Model based on TOGAF ADM [22]	Process-oriented	5	Staged	None explicitly mentioned
Dynamic Architecture Maturity Matrix [23]	Process- & Product-oriented	12	Focus area oriented	Scoring 136 checkpoints
TOPAZ [24]	Process-oriented	None	Continuous	250 control questions
Normalized Architecture Organization Maturity Index [25]	Process-oriented	None	Unknown	SCAMPI
Extended Enterprise Coherence-Governance Assessment [26]	Product-oriented	5	Continuous	50 gradation questions and 20 open questions
Ross' Four Stages [16]	Product-oriented	4	Staged	None explicitly mentioned
Enterprise Architecture Management Maturity Framework [27]	Product-oriented	6	Staged	None explicitly mentioned
Enterprise Architecture Maturity Model [28]	Product-oriented	5	Staged	A toolkit
IT Architecture Capability Maturity Model [29]	Product-oriented	5	Staged	A scorecard
Extended Enterprise Architecture Maturity Model [30]	Process-oriented	5	Staged	None explicitly mentioned
Enterprise Architecture Assessment Framework [31]	Product-oriented	5	Continuous	KPI's with measurable artefacts
IT Capability Maturity Framework [32]	Process- & Product-oriented	5	Staged	Questionnaire
Strategic Alignment Maturity Assessment Description [33]	Product-oriented	5	Staged	High-level process descriptions
Capability Maturity Model Integration [15]	Process-oriented	5	Staged	SCAMPI
COBIT [34]	Process-oriented	5	Staged	None explicitly mentioned
Enterprise Architecture Value Framework [35]	Product-oriented	4	Continuous	Questionnaire

The finer granularity and flexibility of the focus area oriented models provide a good basis for tailoring. Furthermore, this same granularity provides a better step by step improvement schema [20]. Therefore, we chose to use the DyAMM as existing model to serve as a basis for the tailoring.

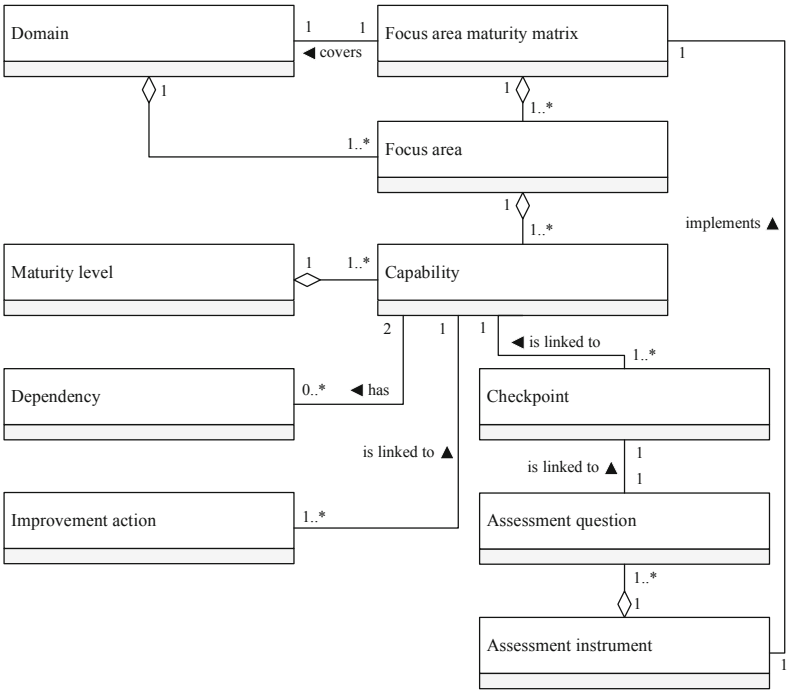

Fig. 2. Metamodel focus area maturity matrix, adapted from [20]

The metamodel of the DyAMM is presented in Fig. 2. The DyAMM is focus area oriented. It has 17 focus areas which represent the performance of the EA function in an organization. Each focus area consists of several capabilities, which represent maturity levels within the focus area. To determine whether an organization fulfills a certain capability within a focus area, checkpoints are introduced. Using the checkpoints, an architecture profile of the organization can be drawn, showing the maturity level of the organization for each focus area. Suggestions for improvement are drawn up for every capability to help organizations improve their maturity. For more detail, we refer to [36, 37].

4 The Tailoring Process

To tailor the matrix towards hospitals, we use a reference EA. This since this is the next step in maturing EA and holds valuable information about a specific domain [8]. It is necessary to know which concepts of the reference EA can be incorporated in which concepts of the DyAMM. Therefore, we constructed meta-models of both the DyAMM and the reference EA in UML class diagrams. As a reference EA we used the 'ZiRA'[1], a reference EA developed by and for hospitals in the Netherlands. The metamodels of a focus area maturity matrix and the ZiRA are depicted respectively in Figs. 2 and 3.

Semi-structured interviews provided requirements for the design of the maturity model specifically for hospitals. These requirements will provide the basis for making the DyAMM specific for hospitals. 3 interviews were conducted to elicit the requirements. Interviewee 1 has 28 years of experience in (healthcare) IT. Interviewee 2 has 18 years of experience in healthcare IT of which 13 as an architect. Interviewee 3 has 37 years of experience in healthcare IT of which 15 as an architect. The most important requirements for tailoring an EA maturity model that derived from the semi-structured interviews are presented in Table 2.

To know which concepts of the ZiRA can be incorporated in the DyAMM, we applied a lens to the metamodels. For the components in both metamodels we analyzed whether that component is process- or product-oriented. The components of the ZiRA are mostly product-oriented, since all the models and viewpoints on the left-hand side are product-oriented. Whereas the principles are both process- and product-oriented. The DyAMM was less straightforward in dividing the components into the two different domains. At the most granular level, the checkpoints, distinction could be made whether a checkpoint encompasses the product, the process, or both dimensions.

The results show that 68 out of the 136 checkpoints of the DyAMM are process-oriented. 53 checkpoints encompass both the domains, and a clear minority of 14 checkpoints are product-oriented. Most of the focus areas are made up of checkpoints that are process-oriented. Only one focus area is mostly made up of checkpoints that are product-oriented.

Table 2. Requirements for an EA maturity model specific for hospitals

Requirement	Source
The model should incorporate parts of the ZiRA	Interviews 2 & 3
The model should evaluate whether the EA is based on standard information concepts	Interview 1
The model should evaluate whether the EA is modular	Interview 1
The model should evaluate the processes involved around the enterprise architecture	Interview 3
The model should evaluate whether the hospital is interoperable in the ecosystem	Interviews 1 & 3

[1] https://sites.google.com/site/zirawiki/.

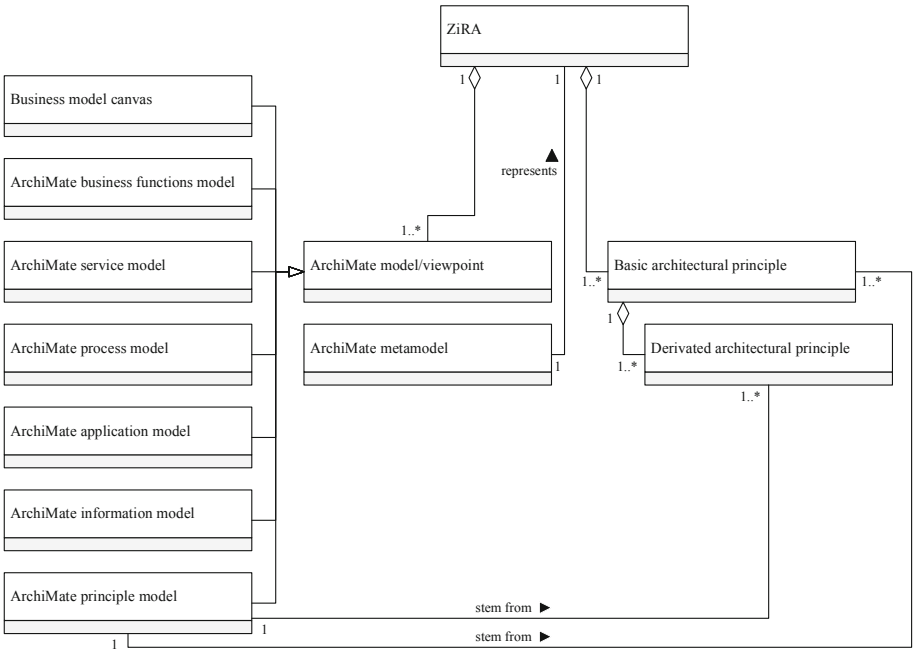

Fig. 3. Metamodel ZiRA

For the tailoring itself, the method described in [4] is used. The steps of designing a focus area maturity model are: (1) identify & scope domain, (2) determine focus areas, (3) determine capabilities, (4) determine dependencies, (5) position capabilities in matrix, (6) develop assessment instrument, (7) define improvement actions, (8) implement maturity model, (9) improve matrix iteratively and (10) communicate results. The first 5 steps are completed in this research, since these make up the scope and design of the initial model. The scope of the model is the EA of hospitals.

Firstly, the focus areas are determined. Interoperability is a main theme in the principles of the ZiRA. It also derived from the semi-structured expert interviews. The DyAMM does not contain a focus area that addresses interoperability. Interoperability was deemed too important and different to incorporate the subject in one of the existing focus areas. Therefore, the focus area 'Interoperability' is added to the model. Also, one of the requirements states that parts of the ZiRA should be incorporated. Most of the knowledge of the ZiRA is incorporated in the ArchiMate models/viewpoints. These are clearly product-oriented concepts, and only one focus area in the DyAMM is mainly oriented on EA products. This focus area however describes the management of the organization's internal architectural product, not whether an external product with its knowledge is involved. Therefore, to fulfill this requirement and to embody the knowledge from these models, we added the focus area 'Utilization of ZiRA models'. From the original focus areas of the DyAMM, none are changed. This since validation through previous research has proved the value of these focus areas [36].

Secondly, the capabilities within the focus areas are determined. Again, from the original capabilities within the original focus areas we did not make fundamental changes. Only some small changes in the wording were made, like replacing 'organization' with 'hospital'. For the new focus areas however, new capabilities must be determined. The capabilities for the focus area 'Interoperability' are based on the Organizational Interoperability Maturity Model [38]. For the focus area 'Utilization of ZiRA models', the capabilities are based on the capabilities from focus areas of the DyAMM that are also (semi) product-oriented.

Thirdly, dependencies and the positioning of the capabilities in the matrix are determined. Prerequisites for the new capabilities derive from other focus areas in the DyAMM. For example, to utilize ZiRA models, first, a hospital should work with such a method. Therefore, capability A from 'Architectural method' is needed. If a capability has another capability as prerequisite, it must be positioned to the right of that capability. And according to [4], it is important to make sure that the capabilities are spread among the different maturity scales to get a more balanced matrix. With these rules of thumb in mind, the capabilities are positioned in the matrix. The result is initially validated and presented in the next section.

The process to apply a reference EA to tailor an EA maturity model towards a specific domain is summarized in Fig. 4. We applied this process and obtained an initially validated domain-specific maturity model. The model itself is presented in the next section in Fig. 5.

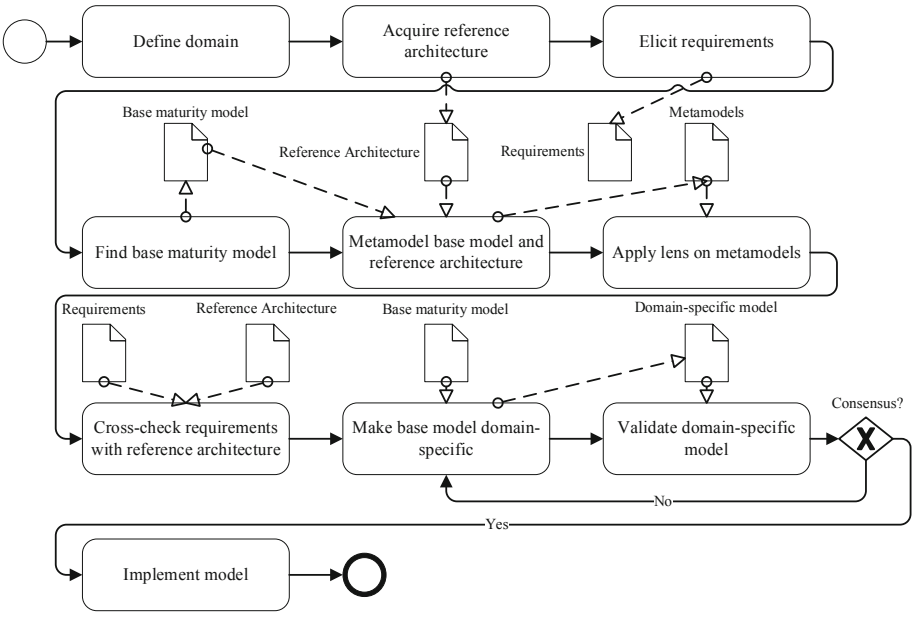

Fig. 4. The tailoring process

5 Initial Validation: A Focus Group Session

We conducted a focus group to initially validate the maturity model as a result from the tailoring process. This initial validation was conducted with the intention to refine the tailoring process and collect evidence on the potential acceptance of the resulting maturity model by architects in the healthcare domain. For the focus group, we follow the protocol prescribed by [13]. The following key design concepts must be defined: (1) the goal of the focus group, (2) the selection of participants, (3) the number of participants, (4) the selection of the facilitator, (5) the information recording facilities and (6) the protocol of the focus group. The goal of this focus group is to gain consensus about whether the execution of the tailoring process, which resulted in additions to the DyAMM, are relevant for assessing the EA maturity of a hospital. The selection of participants was completed from a community of architects in the healthcare domain. An open invite was sent to the community with the following criteria to join: the participant must be a professional who has been working with architecture with at least 3 years of experience in healthcare. From the open invite, 7 participants emerged. Two of them did not meet the criteria to join. However, we did let them participate in the focus group session, since including non-typical participants reduces researcher bias, i.e. the effects of the participants on the researcher [39]. Table 3 shows demographic information about the participants.

Table 3. Participants of the focus group session

Participant	Function	Years of experience in healthcare IT
1	Information architect	10
2	Information architect	25
3	Solution architect	5
4	Enterprise architect	8
5	Data architect	20
6	Freelancer	0
7	Business analyst	2

The main researcher acted as facilitator, since he was most involved in creating the model. The audio was recorded, transcribed and coded in NVivo as means of the information recording facility. Lastly, the protocol of the session was based on the additions made to the DyAMM. For both the new focus areas and all its capabilities, it was asked whether the participants think that that focus area or capability was relevant for assessing the EA maturity of a hospital. They were asked to write on a post-it whether they were positive, negative, or had no opinion about the addition. Whenever there was no unanimous result, a discussion was held to gain consensus about that focus area or capability. After this post-it session, the participants were asked whether they agreed with the checkpoints within each capability.

The results show that the participants unanimously agreed with the focus area 'Interoperability', but that there was some disagreement about the capabilities. It became clear during the discussion that these disagreements mostly involved the phrasing rather than the content. Consensus was reached with choosing the proper phrasing for every capability and its description.

There was no unanimous agreement for the focus area 'Utilization of ZiRA models'. This because some of the participants desired a more generic focus area. One that is not specifically about ZiRA models but also about other domain specific aiding tools. Consensus was reached to change the focus area to a more generic focus area. The first two capabilities within the focus area, were unanimously agreed upon. On the last capability, C, there was another discussion and eventually consensus on the phrasing. Finally, the participants provided some checkpoints from the new focus areas which they also wanted to discuss. There was consensus to remove two checkpoints. Consensus was also reached to change the content of two checkpoints to make them more generic.

Table 4 shows the new focus areas and their capabilities, as initially validated through the focus group session.

Table 4. Capabilities for the new focus areas

Capability	Description
Focus area 'Interoperability'	
A	Ad hoc, limited frameworks are in place which allow for ad hoc interoperability arrangements
B	Collaborative, recognized frameworks are in place to support collaborative interoperability
C	Integrated, shared information services and shared goals on all layers provide integrated interoperability
D	Integral, interoperating by design on a continuing basis makes integral interoperability
Focus area 'Utilization of best-practices'	
A	Ad hoc, when making new architectural products, best-practices are occasionally utilized
B	Structural, best-practices are structurally utilized when making and managing architectural products
C	Embedded, best-practices are embedded in managing the architectural products

The checkpoints of the new focus areas, as formed after validation in the focus group session, are presented in Table 5.

Figure 5 shows the initially validated EA maturity matrix for hospitals. For the descriptions of the capabilities and checkpoints of the original focus areas of the DyAMM, we refer to [37]. The purpose of this figure is to give an indication on how the model looks. The model is not fully elaborated in this paper since the main artefact of this paper is the tailoring process.

Table 5. Checkpoints for the new focus areas

Capability	Checkpoint
Focus area 'Interoperability'	
A	Agreements on interoperability have been made with stakeholders in the ecosystem
A	The architects from involved healthcare organizations do not hesitate to get in touch with one another
B	Message exchange with some stakeholders in the ecosystem is based on standards (e.g. HL7 CDA, HL7 FHIR)
B	Clear agreements are made on which kind of data is exchanged with stakeholders in the ecosystem
C	Exchange of information with stakeholders within the ecosystem is based on established standards
C	The architects from involved healthcare organizations effectively communicate with each other regarding relevant developments in the architectural area
D	Systems store and share information only based on established standards
D	Systems are integrated cross-sector throughout the ecosystem
Focus area 'Utilization of best-practices'	
A	The architects are familiar with the relevant best-practices (e.g. the ZiRA)
A	Best-practices are used as inspiration for the hospital's architectural products
B	The architectural products of the hospital can be linked to best-practices
B	When developing architectural products, best-practices are used as a basis and deviations are substantiated
C	All relevant best-practices are embedded in the architectural products of the hospital

#	Focus Area	0	1	2	3	4	5	6	7	8	9	10	11	12
1	Development of architecture		A			B			C					
2	Use of architecture			A			B				C			
3	Alignment with business strategy		A			B					C			
4	Alignment with realisation			A				B			C			
5	Relationship to the As-Is state					A				B				
6	Responsibilities and authorities				A		B					C		
7	Alignment with change portfolio				A				B		C			
8	Monitoring				A		B		C					
9	Quality assurance								A		B		C	
10	Management of the architectural process							A		B		C		
11	Management of the architectural products					A			B					C
12	Commitment and motivation		A					B		C				
13	Implementation of the architectural role				A		B		C				D	
14	Architectural method				A					B			C	
15	Interaction and collaboration			A		B				C				
16	Architectural tools							A				B		C
17	Budget and planning					A						B		C
18	Interoperability			A			B			C			D	
19	Utilizing domain-specific best-practices					A					B			C

Fig. 5. The EA maturity model for hospitals

5.1 Validity

To increase the validity of the focus group session, some of the methods described in [39] were applied. The participants of the focus group session all worked at different healthcare organizations. This is a form of data source triangulation which increases the legitimation of the evidence. There is an audit trail in place to increase validity as well. Firstly, the raw audio records are available. Secondly, coding the transcription in NVivo provided unitized information.

An inherent validity threat is the researcher bias, since the facilitator was also the main researcher. This bias can and has been reduced by making the researcher's intentions clear at the start of the focus group session and by including non-typical participants [39]. Another validity threat can occur amongst the participants, where they peer pressure each other into a certain decision. This threat was avoided by selecting a heterogeneous sample where none of participants know one another. Also, by letting the participants first write their opinion on a post-it before starting the discussion this threat was reduced.

6 Conclusions

In this paper, we present a process to apply a reference EA for tailoring a domain-specific EA maturity model. This process is executed on the healthcare domain. Therefore, the contribution of this paper is two-fold. The main contribution is this process with the intention to facilitate the tailoring of EA maturity models towards a specific domain with the help of a reference EA. The second contribution is the initially validated maturity model for hospitals, which is a contribution in the field of maturity models for healthcare.

Applying a lens to the metamodels of the reference EA and the base EA maturity model was beneficial. It showed which concepts of the metamodels have similarities and are therefore fit for integration. Especially architectural principles showed to be fit for integration. By using requirements from semi-structured expert interviews, it was ensured that the right alterations were made to the DyAMM, the base model. A more rigorous model was then derived by validating the design through a focus group session with experts.

There are some limitations to this research. Although the model has been initially validated in a focus group, it has not yet been implemented within a hospital. This is a venue for further research, to see whether the model is able to assist in maturing the EA of a hospital. Another limitation is the fact that the alterations to the model are not validated by maturity model experts. A validation with experts in using the DyAMM for example would result in an even more rigorous model. We consider all these aspects as part of our future research endeavors.

Another suggestion for further research is to apply the process to a different domain than healthcare. This will show whether the process is indeed applicable to other domains as well.

References

1. Lankhorst, M.: Enterprise Architecture at Work. Springer, Berlin (2017). https://doi.org/10.1007/978-3-642-29651-2
2. Winter, R., Fischer, R.: Essential layers, artifacts, and dependencies of enterprise architecture. In: 2006 10th IEEE International Enterprise Distributed Object Computing Conference Workshops (EDOCW 2006). IEEE (2006)
3. Meyer, M., Helfert, M., O'Brien, C.: An analysis of enterprise architecture maturity frameworks. In: Grabis, J., Kirikova, M. (eds.) BIR 2011. LNBIP, vol. 90, pp. 167–177. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-24511-4_13
4. van Steenbergen, M., Bos, R., Brinkkemper, S., van de Weerd, I., Bekkers, W.: The design of focus area maturity models. In: Winter, R., Zhao, J.L., Aier, S. (eds.) DESRIST 2010. LNCS, vol. 6105, pp. 317–332. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-13335-0_22
5. Gebre-Mariam, M., Bygstad, B.: The organizational ripple effect of IT architecture in healthcare. In: Proceedings of Twenty-Fourth European Conference on Information System (2016)
6. Romanow, D., Cho, S., Straub, D.: Riding the wave: past trends and future directions for health IT research. MIS Q. **36**, iii–x (2012)
7. Carvalho, J.V., Rocha, Á., Abreu, A.: Maturity models of healthcare information systems and technologies: a literature review. J. Med. Syst. **40**, 1–10 (2016)
8. ten Harmsen van der Beek, W., Trienekens, J., Grefen, P.: The application of enterprise reference architecture in the financial industry. In: Aier, S., Ekstedt, M., Matthes, F., Proper, E., Sanz, J.L. (eds.) PRET/TEAR -2012. LNBIP, vol. 131, pp. 93–110. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-34163-2_6
9. Wieringa, R.J.: Design Science Methodology. Springer, Heidelberg (2014). https://doi.org/10.1007/978-3-662-43839-8
10. Webster, J., Watson, R.T.: Analyzing the past to prepare for the future: writing a literature review. MIS Q. **26**, xiii–xxiii (2002)
11. Wohlin, C.: Guidelines for snowballing in systematic literature studies and a replication in software engineering. In: Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering - EASE 2014, pp. 1–10. ACM Press, New York (2014)
12. Tranfield, D., Denyer, D., Smart, P.: Towards a methodology for developing evidence-informed management knowledge by means of systematic review. Br. J. Manag. **14**, 207–222 (2003)
13. Morgan, D.L.: Focus Groups as Qualitative Research. Sage Publications, Thousand Oaks (1996)
14. Nolan, R.L.: Managing the computer resource: a stage hypothesis. Commun. ACM **16**, 399–405 (1973)
15. Chrissis, M.B., Konrad, M., Shrum, S.: CMMI Guidelines for Process Integration and Product Improvement. Addison-Wesley, Boston (2003)
16. Ross, J.W.: Creating a Strategic IT Architecture Competency: Learning in Stages. MIT Sloan Working Paper No. 4314-03; Cent. Inf. Syst. Res. Working Paper No. 335 (2003)
17. Lakhrouit, J., Baïna, K.: State of the art of the maturity models to an evaluation of the enterprise architecture. In: 3rd International Symposium on ISKO-Maghreb, pp. 1–8 (2013)
18. Nikpay, F., Ahmad, R., Rouhani, B.D., Shamshirband, S.: A systematic review on post-implementation evaluation models of enterprise architecture artefacts. Inf. Syst. Front. 1–20 (2016)

19. Vallerand, J., Lapalme, J., Moïse, A.: Analysing enterprise architecture maturity models: a learning perspective. Enterp. Inf. Syst. **11**, 859–883 (2017)
20. van Steenbergen, M., Bos, R., Brinkkemper, S., van de Weerd, I., Bekkers, W.: Improving IS functions step by step: the use of focus area maturity models. Scand. J. Inf. Syst. **25**, 35–56 (2013)
21. Robertson, E., Peko, G., Sundaram, D.: Enterprise architecture maturity: a crucial link in business and IT alignment. In: PACIS 2018 Proceedings (2018)
22. Proenca, D., Borbinha, J.: Enterprise architecture: a maturity model based on TOGAF ADM. In: Proceedings - 2017 IEEE 19th Conference on Business Informatics, vol. 1, pp. 257–266 (2017)
23. van Steenbergen, M., van den Berg, M., Brinkkemper, S.: A balanced approach to developing the enterprise architecture practice. In: Filipe, J., Cordeiro, J., Cardoso, J. (eds.) ICEIS 2007. LNBIP, vol. 12, pp. 240–253. Springer, Heidelberg (2008). https://doi.org/10.1007/978-3-540-88710-2_19
24. Sobczak, A.: Methods of the assessment of enterprise architecture practice maturity in an organization. In: Kobyliński, A., Sobczak, A. (eds.) BIR 2013. LNBIP, vol. 158, pp. 104–111. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-40823-6_9
25. van der Raadt, B., van Vliet, H.: Assessing the efficiency of the enterprise architecture function. In: Proper, E., Harmsen, F., Dietz, J.L.G. (eds.) PRET 2009. LNBIP, vol. 28, pp. 63–83. Springer, Heidelberg (2009). https://doi.org/10.1007/978-3-642-01859-6_5
26. Wagter, R., Proper, H.A., Witte, D.: The extended enterprise coherence-governance assessment. In: Aier, S., Ekstedt, M., Matthes, F., Proper, E., Sanz, J.L. (eds.) PRET/TEAR - 2012. LNBIP, vol. 131, pp. 218–235. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-34163-2_13
27. United States Government Accountability Office: Organizational Transformation: A Framework for Assessing and Improving Enterprise Architecture Management (Version 2.0) (2010)
28. National Association of State Chief Information Officers: NASCIO Enterprise Architecture Maturity Model, Version 1.3 (2003)
29. United States Department of Commerce: Enterprise Architecture Capability Maturity Model, Version 2.0 (2007)
30. Schekkerman, J.: Extended Enterprise Architecture Maturity Model: Support Guide (Version 2.0) (2006)
31. Executive Office of the President of the US - Office of Management and Budget: Improving Agency Performance Using Information and Information Technology (Enterprise Architecture Assessment Framework v3.1) (2009)
32. Curley, M.: Introducing an IT capability maturity framework. In: Filipe, J., Cordeiro, J., Cardoso, J. (eds.) ICEIS 2007. LNBIP, vol. 12, pp. 63–78. Springer, Heidelberg (2008). https://doi.org/10.1007/978-3-540-88710-2_6
33. Luftman, J.: Assessing business-IT alignment maturity. Commun. Assoc. Inf. Syst. **4**, 1–51 (2000)
34. ISACA: COBIT 2019 Framework: Introduction and Methodology (2018)
35. Plessius, H., Slot, R., Pruijt, L.: On the categorization and measurability of enterprise architecture benefits with the enterprise architecture value framework. In: Aier, S., Ekstedt, M., Matthes, F., Proper, E., Sanz, J.L. (eds.) PRET/TEAR -2012. LNBIP, vol. 131, pp. 79–92. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-34163-2_5

36. van Steenbergen, M., Schipper, J., Bos, R., Brinkkemper, S.: The dynamic architecture maturity matrix: instrument analysis and refinement. In: Dan, A., Gittler, F., Toumani, F. (eds.) ICSOC/ServiceWave -2009. LNCS, vol. 6275, pp. 48–61. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-16132-2_5
37. van den Berg, M., van Steenbergen, M.: Building an Enterprise Architecture Practice. Springer, Dordrecht (2006). https://doi.org/10.1007/978-1-4020-5606-2
38. Clark, T., Jones, R.: Organisational interoperability maturity model for C2. In: Proceedings of 1999 Command Control Research and Technology Symposium (1999)
39. Onwuegbuzie, A.J., Leech, N.L.: Validity and qualitative research: an oxymoron? Qual. Quant. **41**, 233–249 (2007)