ESTABLISHING AN OPTIMAL STANDARDIZED SKILLSET FOR ENTERPRISE ARCHITECTURE.

by

HENDRIK JOHANNES VAN ZYL

Submitted in fulfilment of the requirements for the degree

MASTER OF COMMERCE IN INFORMATICS

in the

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES

University of Pretoria

Supervisor: Dr JP van Deventer

29 November 2021

ACKNOWLEDGEMENTS

The author would like to express his gratitude and appreciation to the people who made this thesis a possibility:

- My Creator for providing the ability, the faculty and me with the knowledge required for the completion of this dissertation.
- My wife and parents for their unconditional love, continued encouragement, and support.
- My supervisor, Dr JP van Deventer, for this guidance, patience, and encouragement during my study, towards the final understanding of the subject matter presented in this thesis.
- My friends who listened to endless discussions related to the content of this thesis.

Finally, I offer my best regards and blessing to all those who supported me during the completion of this project and the conclusion and submission thereof.

Hendrik Johannes van Zyl

DISSERTATION SUMMARY

Title:	Enterprise architecture; Establishing an optimal standardized Skillset.
Author:	Hendrik Johannes van Zyl (u14019932).
Supervisor:	Dr JP van Deventer
Department:	Department of Informatics. Economics and Management Sciences, University of Pretoria.
Degree:	M.Com (Informatics)
Keywords:	Enterprise architecture, Standardization, Skillset, Generic

ABSTRACT

Enterprise architecture (EA) is an evolving discipline that centres around the application of specific EA frameworks and methodologies, which has left a gap in the identification of skill requirements for the discipline. The skill requirements for an enterprise architect centre on the framework and methodology that the enterprise architect employs and does not provide a complete view of generic skill requirements to practice the discipline effectively and efficiently.

In this study, the top four EA frameworks and methodologies are analysed regarding their skill requirements to establish a generic skillset that can be applied to the discipline as a whole and not aligned with a single approach's requirement. Mixed methods were used to analyse the information, where themes within the EA frameworks and methodologies were used to identify the relevancy of specific skills. Furthermore, key literature was determined to tokenize skills which were all standardized into a naming convention. An initial generic skillset is provided through this analysis, which was then evaluated and refined by EA experts from various backgrounds.

The research provides a generic EA skillset, classified into a four-tier importance ranking as well as a layered classification to indicate the type of architectural skill. The findings of this paper help current and prospective EA practitioners to align their skills with the generic requirements for the discipline and provides a deeper understanding of the skill requirements for EA as a discipline and not specific implementations.

GLOSSARY OF TERMS

ENTERPRISE ARCHITECTURE (EA)

- *"Architecture is that set of design artefacts, or descriptive representations, that are relevant for describing an object such that it can be produced to requirements (quality) as well as maintained throughout its useful life (change)" (Zachman, 1997:5)*
- *This study defines EA as a way in which an organisation can be analysed in terms of its components (i.e., its organs) and then be structured so that pertinent aspects such as productivity and communication can be streamlined throughout the organisation.*

SKILLSET

- *"a collection of skills and abilities that can be applied to a professional or creative endeavour." (Merriam-webster.com, 2019)*
- *This study's focus will centre on the application of skills in a professional environment mainly focusing on enterprise architecture skills required to apply enterprise architecture most optimally.*

FRAMEWORK

- *"a basic conceptional structure (as of ideas)" (Merriam-webster.com, 2019)*
- *A framework will be seen in this study as a guiding template that is used to provide an enterprise architecture in a pre-defined manner, that focuses on providing the appropriate and optimal architecture as prescribed by the framework.*

METHODOLOGY

- *"a body of methods, rules, and postulates employed by a discipline: a particular procedure or set of procedures" (Merriam-webster.com, 2019)*
- *A Methodology relating to this study will be the approach used, that guides enterprise architecture in its application.*

GLOSSARY OF ACRONYMS

Enterprise Architecture - EA

The Open Group Architectural Framework – TOGAF

Federated Enterprise Architecture Framework - FEAF

Department of Defence Architecture Framework – DODAF

Architecture Development Method – ADM

Enterprise Architecture Framework - EAF

.

DECLARATION REGARDING PLAGIARISM

The Department of Informatics emphasises integrity and ethical behaviour regarding the preparation of all written assignments.

Although the lecturer will provide you with information regarding reference techniques, as well as ways to avoid plagiarism, you also have a responsibility to fulfil in this regard. Should you at any time feel unsure about the requirements, you must consult the lecturer concerned before submitting an assignment.

You are guilty of plagiarism when you extract information from a book, article, web page or any other information source without acknowledging the source and pretend that it is your work. This doesn't only apply to cases where you quote verbatim, but also when you present someone else's work in a somewhat amended (paraphrased) format or when you use someone else's arguments or ideas without the necessary acknowledgement. You are also guilty of plagiarism if you copy and paste information directly from an electronic source (e.g., a website, e-mail message, electronic journal article, or CD ROM), even if you acknowledge the source.

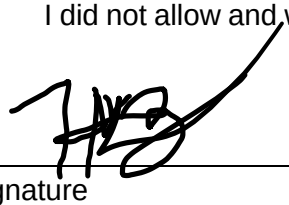
You are not allowed to submit another student's previous work as your own. You are furthermore not allowed to let anyone copy or use your work to present it as his / her own.

Students who are guilty of plagiarism will forfeit all credits for the work concerned. In addition, the matter will be referred to the Committee for Discipline (Students) for a ruling. Plagiarism is considered a serious violation of the University's regulations and may lead to your suspension from the University. The University's policy regarding plagiarism is available on the Internet at *http: / / upetd.up.ac.za / authors / create / plagiarism / students.htm*.

I (full names & surname):	Hendrik Johannes van Zyl
Student number:	u14019932

Declare the following:

1. I understand what plagiarism entails and am aware of the University's policy in this regard.
2. I declare that this assignment is my own, original work. Where someone else's work was used (whether from a printed source, the Internet, or any other source) due acknowledgement was given and reference was made according to departmental requirements.
3. I did not copy and paste any information directly from an electronic source (e.g., a web page, electronic journal article or CD ROM) into this document.
4. I did not make use of another student's previous work and submitted it as my own.
5. I did not allow and will not allow anyone to copy my work to present it as his / her work.



Signature

2021/11/29

Date

Table of Contents

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction

Enterprise Architecture (EA) can be seen as a conceptual view of an enterprises' business processes, IT systems, their relationships to one another (how they have connected) and the extent to which these components are shared throughout the entire enterprise (Tamm, Seddon, Shanks & Reynolds, 2011).

One concern with the EA discipline is the lack of standardisation across frameworks, approaches, and methodologies. As stated by Schöenherr (2008), EA is a "horrible mess" that lacks appropriate structure and core theory. This concern was also identified by Kaisler and Armour (2017) in their identification of Critical Challenges.

This lack of structure for the discipline of EA may also translate to a lack of structure within the skill requirements to implement an effective EA. There are some cases where frameworks provide their skillset, such as the Open Group Architecture Framework (TOGAF) skill framework (Opengroup.org., 2018), but this is not present in all other approaches and frameworks. For example, the Zachman Framework for Enterprise Architecture (Zachman, 1997) does not provide a skill classification/framework.

Employees that are not equipped with the right skills will not perform adequately, and this causes company performance to suffer, whereas employees with the appropriate skills will, in general, perform better (Kumari, 2012). This statement naturally also extends to the field of EA as EA practitioners without the right skills will also not perform effectively. This lack of performance also influences organisations' "cost-benefit ratio" as additional time is spent in the requirement and selection process (Kumari, 2012).

This requirement highlights the importance of a general skillset for EA practitioners that has wide-reaching application across the entire discipline and not only for specific implementations of frameworks/approaches as each framework/approach differs. For example, the Zachman framework focuses on providing a taxonomy for EA (Rajabi, Minaei & Ali Seyyedi, 2013), whereas the Gartner process model focuses on the future architecture and how current implementations can be used to achieve this target (DePalo & Song, 2012).

The selection and recruitment of EA practitioners (employees) is a costly endeavour, and if the practitioner does not have the required skills at their disposal, this will impact the organisation's performance negatively, as stated by Kumari (2012).

This dissertation focuses on the proposition of an optimal standardised skillset for practitioners of EA. The study focused on identifying and providing general skills to be applied to the discipline of EA. The main goal was to provide current and future practitioners of EA with a framework of skills that is generic to the discipline of EA and not limited to a specific framework, approach, and methodology requirements. Furthermore, the paper aims to understand the core skill requirements for practitioners of EA needed better to practice the discipline effectively and efficiently.

The following subsections will provide the background information pertinent to EA skills associated with the discipline. A detailed problem statement will be provided to identify what the research aims to address. Furthermore, the research questions and objectives will be provided along with the limitations and definitions. Within this section, the motivation for doing the research is provided, and lastly, the chapter overviews are shown to give a high-level description of each subsequent chapter in this study.

1.2 Background Information

Enterprise Architecture (EA) can be defined and seen from numerous viewpoints. Some of the definitions of EA within a business setting can be summarised as follows.

EA can be described as a process of defining and describing an enterprise through descriptive representations of its real-world counterparts that allow the organisation to produce and maintain suggested solutions according to specifications laid out by management (Zachman, 1997, p.5).Iyer and Gottlieb (2004) see EA (in the IT context) as the decomposition of an enterprise and the appropriate identification of decomposed components and their relationships to one another (Iyer & Gottlieb, 2004:587). EA can be seen as a conceptual view of an enterprises' business processes, IT systems, their relationships to one another (how they have connected) and the extent to which these components are shared throughout the entire enterprise (Tamm, Seddon, Shanks & Reynolds, 2011).

The main theme identified within these definitions is that EA seeks to describe the components of an enterprise and identify how these components are interwoven, i.e., the relationships between these components. Hoogervorst (2004) states that EA plays a role in enabling the integration, agility, and ability to change in organisations. Furthermore, he says that these three areas are becoming increasingly important for organisations as the business world evolves. He concludes that organisations should invest their efforts in EA as it will help improve these identified areas. (Hoogervorst, 2004).

EA can provide organisations with benefits in domains such as identified by Hoogervorst (2004). According to Ovidiu, "*Any business entity aspiring to a lasting presence in today's ever-changing environment must adapt to its surroundings, via change processes of its own*" (Ovidiu, 2003:165). This necessity to adapt and provide an appropriate structure for organisational assets, where it is lacking, identifies a possible purpose for EA, to make sense of the chaos and provide a roadmap to the proper structuring of an organisation's assets for change. This structure that EA provides is made possible through the tools utilised by an enterprise architect. These tools mainly consist of architectural frameworks and methodologies.

One of the first enterprise architecture implementations can be traced back to the "*Partnership for Research in Information Systems Management*" (PRISM, 1986)**.** Kotusev (2016) states that that the core ideas of EA originated from Business Systems Planning (BPS), developed by IBM, and that PRISM contributed to this foundation. Even though PRISM and BPS can be seen as the first implementations of EA, the Zachman taxonomy for EA is considered by many as the first proper implementation of EA. Kotusev (2016) stated that the main consensus of publications is that the Zachman Framework is a seminal publication of EA. (Kotusev, 2016)

There are many different EA approaches and frameworks. The main EA frameworks used, as indicated by Cameron and McMillan (2010), are TOGAF, the Federated Enterprise Architecture Framework (FEAF), the Zachman Framework for Enterprise Architecture and Gartner (Cameron & Mcmillan, 2010). The study focused on these four frameworks.

Each of these frameworks provides a different approach to the implementation of EA. For example, Zachman focuses on providing a taxonomy for EA (Rajabi et al., 2013), where the Gartner process model focuses on the future architecture and how current implementations can be used to achieve this target (DePalo & Song, 2012). These different approaches are justified within their reach of application, but then the application of EA will require the practitioner to define its scope. This approach may cause a division within organisations as an implementation of EA ultimately falls into the hands of the architect. As stated by Riwanto et al. (2019) with regards to TOGAF, FEAF and Zachman's frameworks, that "*every organization*" differs in its implementation and approach of these frameworks (Riwanto et al., 2019:1).

Sessions (2007) states in his paper that there is generally a distrust in organisations between IT and business employees and departments and that no methodology can rectify this unless there is a commitment to change. He states that "*Methodologies cannot solve people problems; they can only provide a framework in which those problems can be solved*" (Sessions, 2007). In a Gartner report Drobik (2002) states that there is a divide between IT

and Business departments regarding EA and that the application of EA should be organisational-wide (Drobik, 2002). This emphasises the importance of an organisational-wide approach to EA and its implementation.

EA's origins (to a practical level) can be traced back to the Zachman Enterprise Architecture framework. From this framework, other frameworks emerged, each to suit their pre-defined purpose.

EA is a discipline that can provide organisations with the structure they need to operate optimally. The Zachman framework has led to the emergence of many frameworks, each trying to fill a certain gap that previous and already existing frameworks lack focus on. These implementations and success of EA ultimately fall onto the practitioner thereof and the skillset at their disposal.

The lack of standardization within the discipline of EA has left a gap in the identification of required skills; these skills need to be identified for EA to continue its path towards a unified discipline, all be the implementation thereof case-specific.

In the following section, we will consider the problem statement where the main problem is defined. This would lead us to the presentation of the main research question for this thesis.

1.3 Problem Statement

Enterprise Architecture (EA) enables the structural creation of a "set of descriptive representations" that are used to describe an "object", business asset or process, to name a few, so that it can be produced according to the identified specification and "maintained" while in operation. (Zachman, 1997:5). This statement suggests that EA allows the practitioner to communicate complex organisational structures in a structured way that can guide the implementation of business objectives or strategies and facilitate the maintenance of delivered business objects, processes or assets. Thus EA acts as a "roadmap" that guides the organisation's strategic planning, implementation, and support.

This implementation of EA can provide an organisation with an abundance of benefits such as; enabling the integration, agility, and ability to change (Hoogervorst, 2004).

The problem is that EA can only provide these benefits when applied correctly, according to the current context of the organisation (i.e., the business need). Drobik (2002) indicates a lack of proper alignment between the IT and business departments of most organisations as each department focuses on its requirements rather than the broad organisational need as a whole. (Drobik, 2002). Furthermore, organisations do not always appreciate EA's value for them

(Kaisler & Armour, 2017). The enterprise architect will thus need a set of skills to provide an architecture that will benefit the organisation (business and IT). EA has a multitude of approaches, methodologies, and frameworks to bring forth this value.

These EA approaches do not only centre on business-related areas. An example of this can be The Department of Defence Architecture Framework (DoDAF) which is mainly used to control the value chain of military operations (U.S. Department of Defense, 2010). Although DoDAF employs the same principles as any other EA framework, the DoDAF framework is more military-focused and will likely not work in other, more business-centred organisations. Another example can be the Open Group Architectural Framework (TOGAF). This framework is more suited to information technology and business applications. (Opengroup.org, 2018)

The problem faced is that there is a lack of a defined skillset for the application EA in general. Each framework might provide a skillset for its use, an example being TOGAF, and there might be overlap between the skillsets, but there is a lack of an all-encompassing skillset identified for the application EA in general. Dang and Pekkola (2016) identified eight root causes of problems within EA, one of them being the capability and ability of the EA team, and stated, "*The EA teams and their abilities and skills significantly affected the EA results*" (Dang & Pekkola, 2016:183) This statement further emphasises the importance of appropriate skills within the EA discipline and shows that the EA practitioner will require the skills needed to deliver a beneficial solution to an organisation.

Schöenherr describes EA as a "horrible mess" that lacks the appropriate structure and core theory. (Schöenherr, 2008:1) The article focuses on the lack of a common terminology of EA through the analysis of 129 references. This was also concluded by Kaisler and Armour (2017) in identifying critical challenges for EA (Kaisler & Armour, 2017). This finding emphasises the issue currently within the discipline, as this may be an issue that causes confusion and a sub-optimal implementation. Because of this lack of commonality across EA, the required skills for the discipline are loosely defined according to the architecture's current implementation (the implemented framework and approach) rather than the discipline's overarching skill requirements.

The purpose of this research is to define an optimal standardised mix of skills for EA practitioners that has a wide-reaching application for the discipline rather than focusing on a specific instance of use. In his identification of the top ten needed skills in the workplace, Robles (2012) states the importance of soft skills and indicates that they are an equal indicator to technical skills in predicting job performance (Robles, 2012). This study will only look at the technical skill requirements for EA practitioners as a baseline of generic skill requirements but

does not deny the importance of soft skills that may impact the efficiency and effectiveness of an EA practitioner.

Thus, to conclude, the problem faced is a lack of a defined, generally applicable and acceptable EA skillset that takes the entire discipline into account. The identification and provision of such a skillset will provide practitioners of EA (the audience) with a guideline, in terms of skills required, to implement an Enterprise Architecture that will prove to be beneficial in practice.

1.4 Research Questions and Objectives

Based on the considerations, we can therefore state the main research question as follows:

What is the optimal and generally acceptable skillset for Enterprise Architecture practitioners?

The following research sub-questions will pave the way to answer the main question:

1. What are the required skills to practice the top four Enterprise Architecture frameworks or approaches?
2. How can a generic skillset for Enterprise Architecture practitioners be classified?
3. What are the focus points (regarding skills) for enterprise architects?
4. What is the inter ranking of skills, regarding their importance, to practice Enterprise Architecture in general?

The objectives of the research questions are:

1. To identify the main skills an enterprise architect requires in the discipline of Enterprise Architecture concerning the top four EA frameworks
2. To identify generic Enterprise Architecture skills for practitioners that can be applied as a general foundation to the entire discipline of EA
3. To identify the inter-skill importance of generic Enterprise Architecture practitioner skills.

The research questions and objectives provide a starting point and direction that the study can pursue to achieve its main goal of identifying a generic skillset for EA practitioners. The research questions and objectives focus the research by aligning research efforts with the primary goal of providing a structure for the research to occur.

1.5 Limitations, Delimitations, and key Assumptions

The following limitations indicate areas that will not be covered in this research paper:

- This study only focuses on EA skills relevant to the discipline and generic enough to be applied to the discipline. Thus, although there might be arguments for the relevance of other skills outside the domain of EA, the skills for EA practitioners are the focus.
- There is a multitude of EA approaches and frameworks. This study focuses only on the top four EA approaches or frameworks and the skills identified within the scope of each skill.
- Soft skills are not included in the skillset classification. This decision is to ensure that the study can focus on specific EA orientated skills and does not stray from the core objectives of the study.
- This study focuses on research, papers, and articles written up to 2021 as the entire body of knowledge related to EA is ongoing.

1.6 Motivation for Conducting This Study

As noted, EA is an evolving discipline that can provide an abundance of benefits to an organisation if applied correctly, such as: enabling the integration, agility, and ability to change in organisations (Hoogervorst, 2004:18). Because EA is still evolving, a multitude of disconnected frameworks and methodologies exist. As stated by Schöenherr (2008), EA is a “horrible mess” that lacks the appropriate structure and core theory. (Schöenherr, 2008:1). This disparity of clear guidelines imposes a challenge for practitioners of the discipline as the skills required to implement one framework might be nullified in the implementation of another.

The motivation for the research is to define an optimal mix of skills within EA that has wide-reaching application for the discipline regarding a required skillset.

The provision of such a skillset could provide practitioners of EA with a baseline of generic skills for the discipline of EA to refine their own skillsets. The proposed skillset may also provide a reference for prospective EA practitioners to align their skillsets with, rather than the skill requirements for a specific EA approach or framework. Furthermore, the definition of such a skillset will provide a better understanding of the core skill requirements for EA as a discipline, thus for EA as a whole and not subdivided into specific implementations.

1.7 Contribution

This research paper focuses on providing a generally acceptable and applicable skillset for Enterprise Architecture (EA). As discussed in the sections above, EA lacks a generic skillset that considers the whole discipline's skill requirements for practitioners.

The end goal of this study is to provide a proposed skillset for the discipline in general through the analysis of the top four EA frameworks or approaches and expert interviews to refine the skillset.

The contribution of this study is the provision of this skillset. This skillset contributes to a better understanding of the field of EA as this study aims to provide this optimal mix of skill requirements. The lack of a general skillset for EA may result in a barrier to entry for prospective EA practitioners, as the current approach is to "choose" a framework or approach and align your skillset with the skills required for the approach. This approach is not necessarily unjustified, but the lack of a general skillset for the discipline funnels its skill requirements into the narrow (relative) scopes of each framework or approach. Thus, another expected contribution is the provision of a generic skillset to practitioners of EA that can serve as a foundation of skill requirements for the discipline. This skillset may help the EA practitioners or future practitioners align their skillsets with the one proposed, thus providing a guide in acquiring generic EA skills that are not isolated to a specific EA framework or approach.

To conclude, the contribution of this study is twofold; firstly, and most importantly, the provision of an EA skillset that is generic enough so that it can be applied to EA as a discipline and not specific implementations, thus providing a standardised optimal mix of skills not focused on isolated implementations. Secondly, to provide a better understanding of the optimal standardised skill requirements of EA in general that can serve as a foundation for skill requirements for current and future EA practitioners.

1.8 Chapter Overviews

Chapter 1 (Introduction and Background): This paper's introduction and background section establish a foundation for the following chapters. Within this chapter, the background for the study is provided that describes any pertinent information about the topic. Furthermore, this section provides a problem statement that describes why the research question has been chosen. This chapter also includes the main research question, followed by sub-questions that will be examined in this study. The objectives for the study are also provided that link with the

sub-questions posed. Lastly, this chapter provides the limitations, clarifications, definition of terms used in the study and the motivation for doing the research.

Chapter 2 (Literature Review): This chapter focuses on obtaining reliable information about the topic at hand to help understand and drive the main research question towards a conclusion. This section also serves as the foundation of the research, where information will be sought and used in the pursuit to answer the sub-questions and main research question.

Chapter 3 (Research Methodology): This chapter explains the research methodology used in carrying out the research. This chapter will explain the research philosophy and strategy used. Furthermore, this chapter will explain how the data was gathered for the analysis section of the paper. This section will also explain the way the data will be analysed. Lastly, the ethical concerns of the paper will be discussed.

Chapter 4 (Analysis, Discussion and Results): This chapter focuses on the analysis of the data gathered. This section entails the analysis of captured data and a discussion of the results. This chapter aims to use the results to answer the main research question posed in this paper.

Chapter 5 (Conclusion): This chapter marks the end of the research paper. This chapter will provide a summary of the findings throughout the research. This chapter also provides the conclusion for this paper and a summary of contributions. Lastly, this chapter provides future research ideas that will help further the knowledge spectrum of Enterprise Architecture.

1.9 Chapter Map

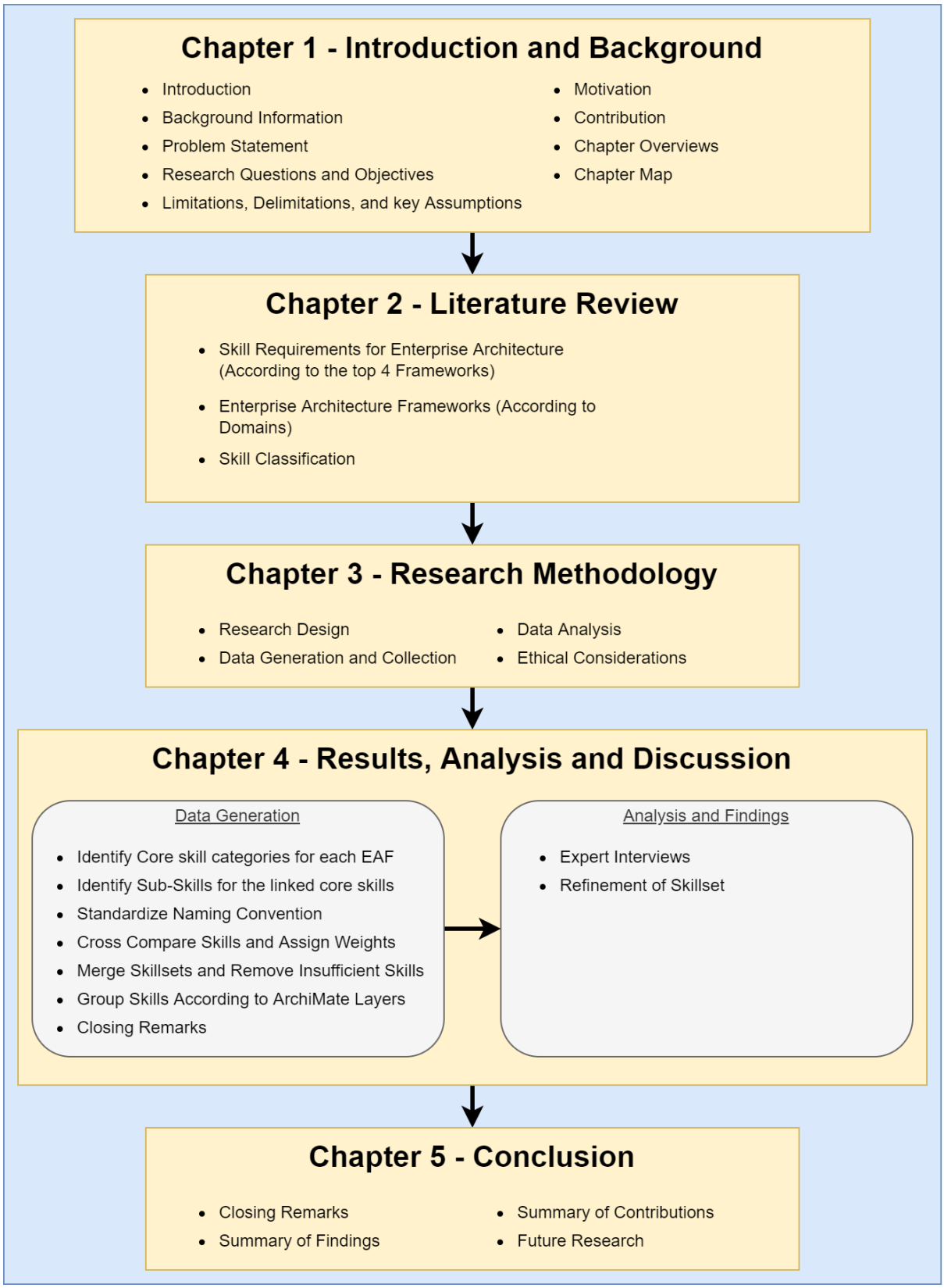


Figure 1. Chapter Map

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

To implement an EA that provides benefits such as; enabling the integration, agility, and ability to change in organisations (Hoogervorst, 2004:18), the EA practitioner will need the required skillset to implement the architecture effectively, as the capability, skills and ability of the EA team will influence the EA outcome (Dang & Pekkola, 2016:183).

The Enterprise Architecture Frameworks (EAFs) that are used in the study are the Open Group Architectural Framework (TOGAF), Federated Enterprise Architecture Framework (FEAF), the Zachman Framework for Enterprise Architecture and the Gartner Framework. These frameworks were chosen as they are the most used EAFs identified by Cameron and Mcmillan (2010). Because these frameworks are the most widely used, the argument can be made that the skills required to implement these frameworks are seen as satisfactory and core to the discipline and are used as the starting point for skill identification in this study.

The lack of a core theory and appropriate structure for EA, as identified by Schöenherr (2008), emphasises the current disconnect in the discipline.This lack of commonality highlights the need for a standardised skillset for the disciplines as a whole and not subdivided into specific implementations.

The following chapter provides information from reliable sources to form the literature review for this study. The literature obtained will give the reader valuable insights into the topics of the study and lay a foundation for the research that will ensue.

This structuring provides a well-rounded analysis of the literature available on this topic so that the required research can follow. The literature review also includes personal remarks on the literature and identification of any gaps within the reading material. This structure will provide a better understanding of the need for the research while providing pertinent information that will help answer the main research question in this paper.

2.2. Skill Requirements for Enterprise Architecture

The underlying sub-heading will be used to identify the skill requirements for EA. This structure aims to split each of the areas viewed in the literature review into concise focus points. The focus points in the literature review are to analyse the four EAFs that are looked at in this study. The information acquired from this analysis will then be used to ascertain if the core concepts of the frameworks can be structured into a concise grouping, and lastly, the skills

classification framework is discussed that will be used to standardise the naming conventions across all frameworks, with regards to a required skillset:

- Enterprise Architecture Frameworks
- Enterprise Architecture Framework according to domains
- Skill classification or view

The four EA frameworks that will be looked at are The Zachman Framework, The Open Group Architectural Framework, the Federal Enterprise Architecture Framework, and the Gartner Framework. These frameworks are chosen because they are the top four EA frameworks employed, as Cameron and McMillan (2010) indicated. The top four EA frameworks are analysed to ensure that the study can be conducted concisely and limit any noise introduced by less used frameworks. As these frameworks are the most used, they guide what the industry has identified as valuable frameworks and as an extension EA application and skills.

The analysis of the EA frameworks will indicate the skill requirements for each framework alongside overarching core concepts. The domain classification will provide a structure and alternative viewpoint where the skills can be categorised. Lastly, the skill classification provides a standardised categorisation into which the identified skills can be combined. The skill classification allows the standardisation of skill naming conventions across the four EAFs.

2.2.1. Enterprise Architecture Frameworks

The following sub-headings will provide information on each of the four EAFs looked at in this study. Each framework is focused on sequentially, analysed and discussed to understand the framework at hand. This section serves as a starting point to the skills analysis of each EAF, providing a foundation and information root upon which the analysis can expand to provide an initial skillset to be evaluated by EA experts. The information acquired from each framework will be used in the next section, where core concepts are used to identify a possible classification method of skills used when providing the initial skillset iteration.

2.2.1.1. The Zachman Framework

The Zachman Framework for Enterprise Architecture's implementation "*defines the artifacts that are needed to fully define an enterprise*" (Osvalds, 2001:3). The framework can be used as a "*general guide*" where the organisation can select the appropriate sections of the framework to implement (Cardwell, 2007:5).

Zachman (1997) states that in his creation of the Zachman framework, he was able to identify five perspectives and six characteristics. He says that these perspectives identify the different

ways the end product of EA can be viewed and that the different characteristics are used because it is easier to view a result when a single characteristic of the end product is isolated and viewed separately at a time (Zachman, 1997).

The perspectives that Zachman (1997) identified became the row descriptors of the framework. These perspectives are the scope, owner, design, and builder. The characteristics form the column descriptors and are identified as the what, how, when, who, when and why. (Zachman, 1997).

These intersections of perspectives and characteristics (gird/matrix) provide all the requirements for EA (Rajabi et al., 2013). Rajabi et al. (2013) state that the Zachman framework provides a more complete taxonomy when compared to FEAF, TOGAF and DODAF and that this taxonomy is "*almost the entire focus of Zachman*" (Rajabi et al., 2013). Each intersection or cell provides an "*outcome of an architecture activity*" (Abdallah & Galal-Edeen, 2006). Thus, when selecting a perspective and characteristic, the intersecting cell describes the architectural artefact to produce.

Zachman (2008) provides model names for each row in the framework and thus provides a further classification viewpoint of the model. Zachman (2008) identifies the first row as the "Scope Contexts", the second row as the "Business Concepts", the third row as the "System Logic", the fourth row as the "Technology Physics", the fifth row as the "Tool Components" and lastly, the sixth row as the "Operations Instances" (Zachman, 2008).

The Zachman framework provides a generic structure for implementing EA that centres on the simplification of complex objects by arranging these objects into the different viewpoints of perspectives and characteristics that provide a classification for these objects. (Zachman, 1997). Thus, the Zachman framework offers a way to break up complex problems in a structured manner to be understood more easily and thus simplify the complex process of providing an EA.

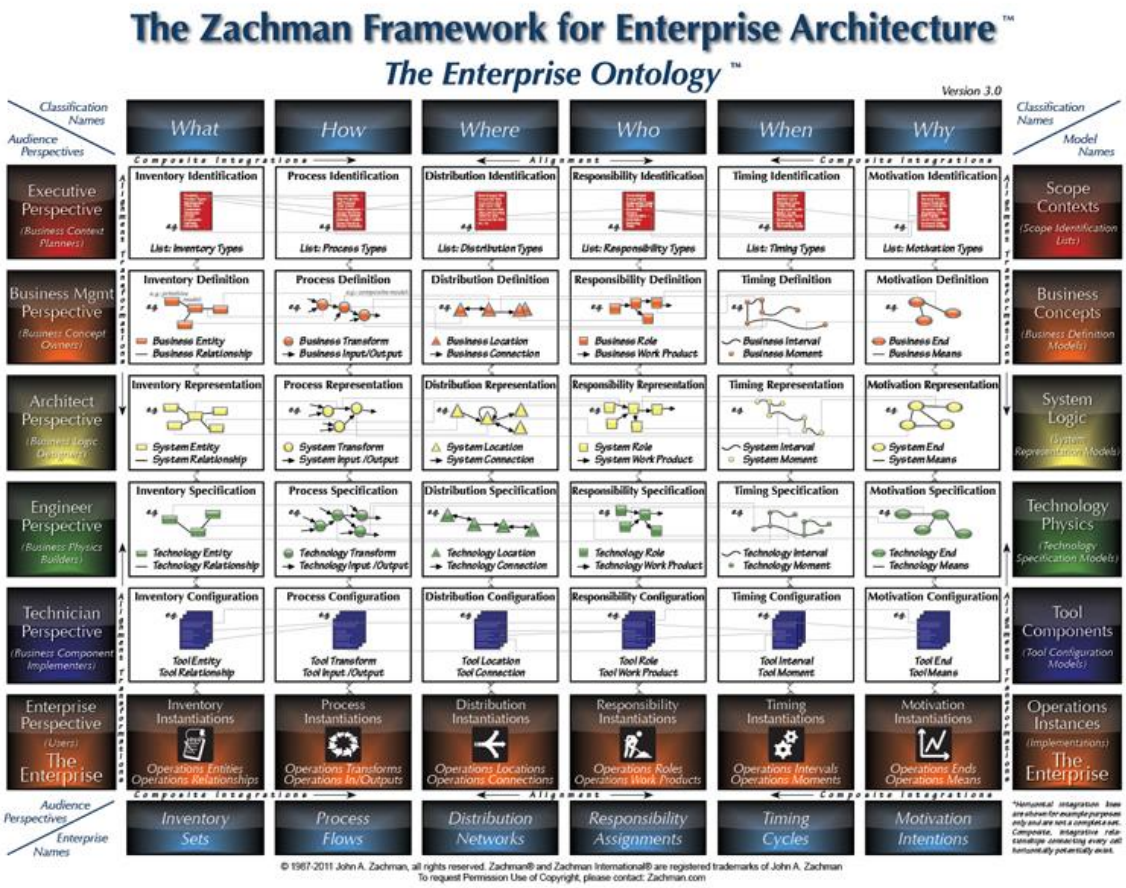


Figure 2. The Zachman Framework (Zachman, 2008)

An important note about the Zachman framework is that it is a generic framework. This means the framework can be used to depict almost anything where an object can be broken down into sub-components making up the whole. (Zachman, 1997). This statement implies that when this framework is looked at regarding its required skills, the skills required will largely be influenced by the context of the framework. Naturally, a baseline of skills to implement the architecture will be required regardless of the focus for its implementation, but the context the architecture is used in may influence the skills required.

The Zachman framework also does not provide a defined methodology for implementation (Kang et al., 2010:1457). Therefore, other methodologies, for example, TOGAF methodology, could be used to implement this EA framework. Although the Zachman framework does not provide a methodology for its implementation, the framework is valuable in that it offers a generic framework that any organisation can use to create an EA (Kang et al., 2010:1457). Organisations can thus use a preferred methodology to implement the framework that suits

their current needs, and as the framework is generic, it can be used to implement enterprise architecture in any organisation as identified by Kang et al. (2010).

Zachman (1997) is aware of the generic nature of the framework (although not aimed at skills required), as he states that the question should be asked as to where the boundaries of an enterprise lie for which the framework will be used. Zachman answers this question by asserting that the business assets and functions that contribute to an organisational mission or set of objectives lay the boundaries for the enterprise. (Zachman, 1997). Extending Zachman's question, one could ask what skills should be associated with this scope in line with his identification of the boundaries of an enterprise.

2.2.1.2. The Open Group Architectural Framework (TOGAF)

TOGAF will be discussed in this section. Firstly, a brief overview of TOGAF will be provided with special remarks towards TOGAF Architecture Development Method (ADM) and ArchiMate framework. After this description, the specific skills as identified by TOGAF will be discussed.

TOGAF is an approach to EA that mainly centres on improving an organisation's efficiency (Opengroup.org., 2018.) and "*provides a focus for the design, planning, implementation and governance of an EA*" (Cabrera et al., 2015:113).

TOGAF provides both a methodology as shown in *Figure 4* and a framework through the ArchiMate core framework, as shown in *Figure 3*.

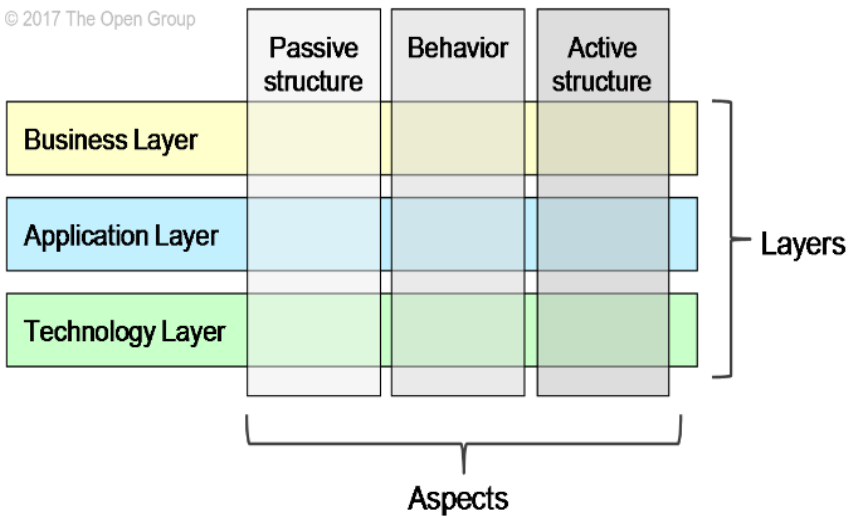


Figure 3. ArchiMate Core Framework (Opengroup.org, 2017)

This framework identifies three architectural layers: the business layer, the application layer, and the technology layer. These layers intersect with three aspects: the passive structure, the behaviour, and lastly, the active structure.

The active aspects focus on "*execution of behaviour*", while the behavioural aspects focus on the "*actual behaviour*", and lastly, the passive aspects focus on the "*concepts*" where this "*behaviour is preformed*" (Lankhorst et al., 2009:8)

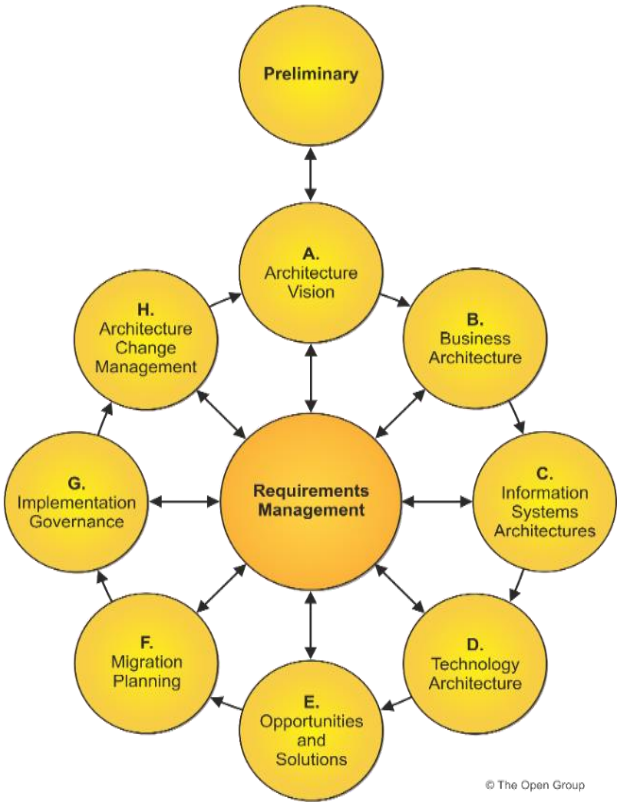


Figure 4. TOGAF ADM (Opengroup.org., 2018)

TOGAF's ADM, as shown in *Figure 4*, specifies "*guidelines*" for implementing an EA (Buckl et al., 2009). TOGAF's methodology is subdivided into nine phases. These phases are preliminary, architecture vision, business architecture, information systems architecture, technology architecture, opportunities and solutions, migration planning, implementation governance and architecture change management. Buckl et al. (2009) state that the "*guidelines*" provided by the ADM are generic and may not be "*applicable*" for certain organisations (Buckl et al., 2009:38).

Bondar et al. (2017) state that the ADM can be "*tailored*" by organisations and should be viewed as a "*guide*" and not as a rigid set of steps that need to be followed and that the generic nature of the ADM aims to address most requirements in organisations, regarding their architectural development (Bondar et al., 2017)

When comparing these two statements, it is interesting to note that there are concerns raised about the generic nature of the ADM and that it may not be a perfect fit for all organisations, as stated by Buckl et al. (2009). Instead, this ADM's generic nature aims to address most architectural requirements for organisations that can be customised to fit their needs, as Bondar et al. (2017) stated. This generic structure may be one reason why TOGAF is so widely used, as it seems to be a "one size fits all" approach echoing back to the observations made when looking at the Zachman framework.

An important note that can be taken away from TOGAF methodology is the emphasis placed on requirements management at each phase of the ADM, as shown in *Figure 4*.

The methodology shows that an EA starts at a preliminary investigation and then works through the phases, as shown in Figure 4, where requirements management influences each phase. This can be considered when identifying the skills required for performing EA, as the architect will need to be able to manage requirements effectively in providing the architecture to satisfy the organisation's needs.

The ADM indicates that purely technical skills may bring shortcomings to the EA practitioner application, as they may need, for instance, project management skills to manage the requirements of the EA project as indicated on TOGAF's skills framework (Opengroup.org, 2018.)

ArchiMate aligns with TOGAF ADM and provides "*a commentary on the different parts of the ArchiMate Specification*" (Jonkers et al., 2009:11). This commentary provides alignment between the ArchiMate specification and TOGAF ADM. An example of this is shown in *Figure 5*.

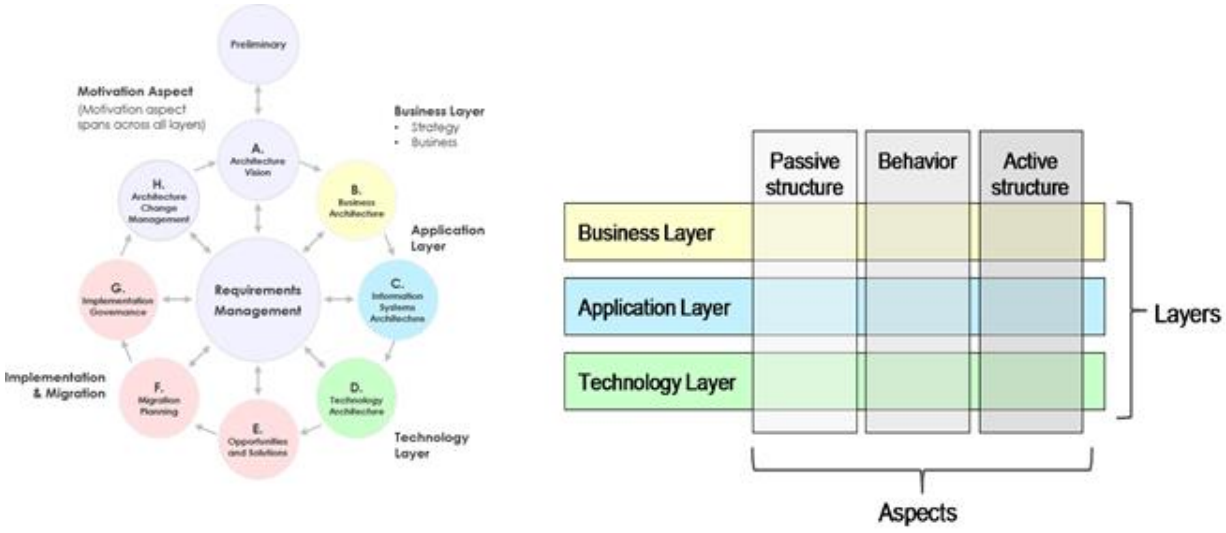


Figure 5. TOGAF ADM aligned with ArchiMate Framework. Adapted from (Opengroup.org 2017) and (Opengroup.org., 2018)

Figure 5 shows how TOGAF ADM and the ArchiMate framework have interdependence with each other. Thus, TOGAF ADM provides a process of work to provide an EA while the ArchiMate framework provides a structure to organise EA within the business, application, and technology layer.

The Open Group also provides a content metamodel, as shown in *Figure 6,* that identifies all the components that may be used and created within the EA process. Gerber et al. (2010) state that the content metamodel provided by TOGAF will "*play a crucial role*" in future developments of EA based on the "*importance and adoption of TOGAF 9*" (Gerber et al., 2010:58). This statement highlights the importance of TOGAF in the EA domain and as an extention the content metamodel provided.

The core metamodel components are derived from the terminology "*used to define*" the ADM (Gerber et al., 2010). The content metamodel identifies how TOGAF ADM and Archimate framework fit into each other. A clear section within the content metamodel identifies the business, data and application, and lastly, the technology architectures (as shown in the ArchiMate framework).

Thus all the phases in TOGAF ADM are also provided in the content model. This content metamodel represents how EA functions and how the deliverables of EA are structured and categorised. Thus moving through the entire process, from current architecture to the proposed architecture, identifying the gaps and providing guidelines/governance in filling these gaps and as a result implementing the architecture.

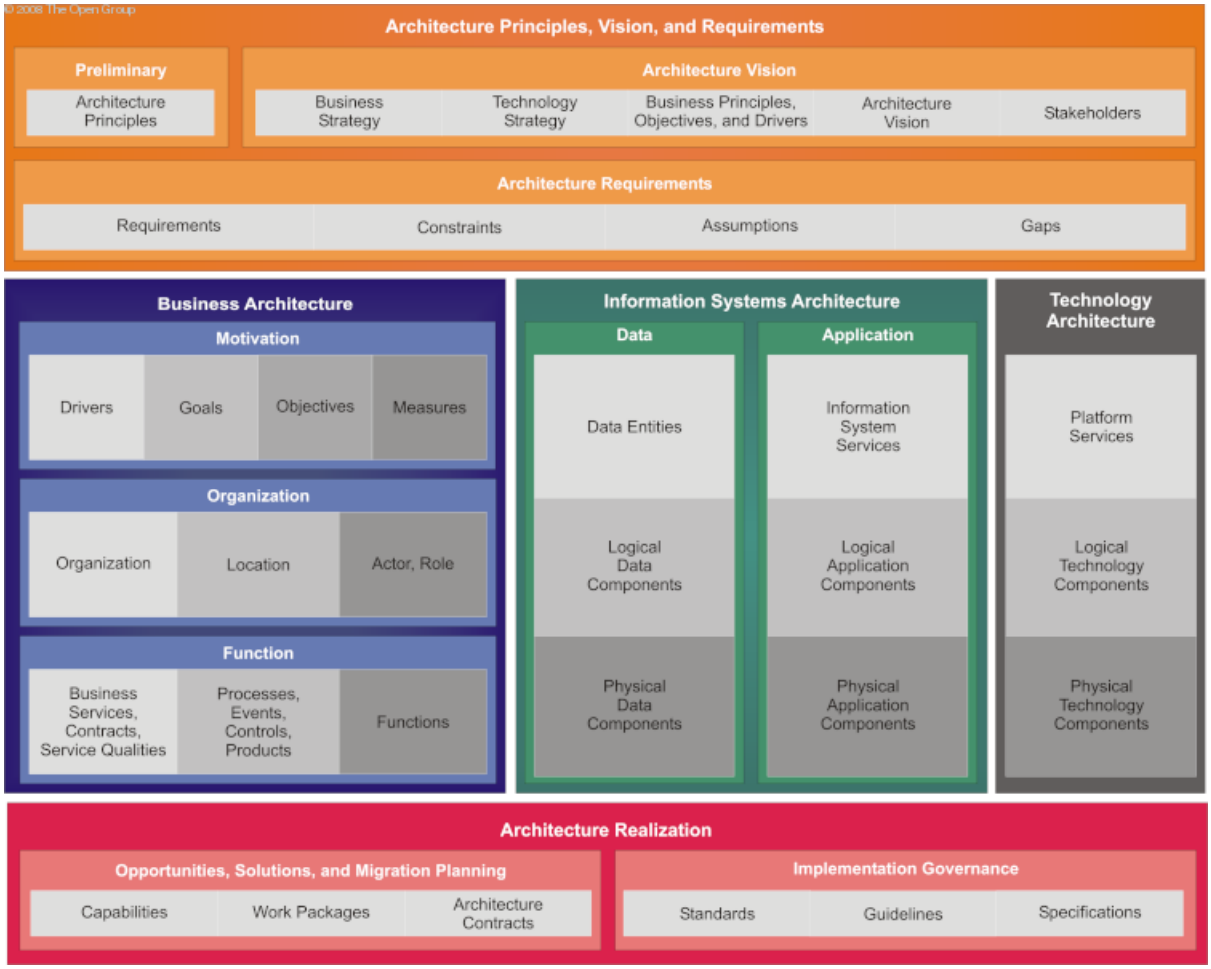


Figure 6. TOGAF content metamodel (Opengroup.org., 2018)

The Open Group also provides a skills classification for TOGAF. This skill classification is divided into seven sections: Generic skills, business skills and methods, enterprise architecture skills, program or project management skills, IT general knowledge skills, technical IT skills and legal environment. This skillset is then assigned a rank according to the level of importance in an IT Architect role (Opengroup.org, Opengroup.org., 2018).

An example of this skill classification and the proficiency levels can be seen in *Figure 7*. The proficiency levels range from 1–4, with 4 being the most proficient level.

IT Architect Roles	Architecture Board Member	Architecture Sponsor	IT Architecture Manager	IT Architecture Technology	IT Architecture Data	IT Architecture Application	IT Architecture Business	Program or Project Manager	IT Designer
Enterprise Architecture Skills									
Business Modelling	2	2	4	3	3	4	4	2	2
Business Process Design	1	1	4	3	3	4	4	2	2
Role Design	2	2	4	3	3	4	4	2	2
Organization Design	2	2	4	3	3	4	4	2	2
Data Design	1	1	3	3	4	3	3	2	3
Application Design	1	1	3	3	3	4	3	2	3
Systems Integration	1	1	4	4	3	3	3	2	2
IT Industry Standards	1	1	4	4	4	4	3	2	3
Services Design	2	2	4	4	3	4	3	2	2
Architecture Principles Design	2	2	4	4	4	4	4	2	2
Architecture Views & Viewpoints Design	2	2	4	4	4	4	4	2	2
Building Block Design	1	1	4	4	4	4	4	2	3
Solutions Modelling	1	1	4	4	4	4	4	2	3
Benefits Analysis	2	2	4	4	4	4	4	4	2
Business Inter-working	3	3	4	3	3	4	4	3	1
Systems Behavior	1	1	4	4	4	4	3	3	2
Project Management	1	1	3	3	3	3	3	4	2

IT Architect Roles	Architecture Board Member	Architecture Sponsor	IT Architecture Manager	IT Architecture Technology	IT Architecture Data	IT Architecture Application	IT Architecture Business	Program or Project Manager	IT Designer
Business Skills & Methods									
Business Case	3	4	4	4	4	4	4	4	2
Business Scenario	2	3	4	4	4	4	4	3	2
Organization	3	3	4	3	3	3	4	3	2
Business Process	3	3	4	4	4	4	4	3	2
Strategic Planning	2	3	3	3	3	3	4	3	1
Budget Management	3	3	3	3	3	3	3	4	3
Visioning	3	3	4	3	3	3	4	3	2
Business Metrics	3	4	4	4	4	4	4	4	3
Business Culture	4	4	4	3	3	3	3	3	1
Legacy Investments	4	4	3	2	2	2	2	3	2
Business Functions	3	3	3	3	4	4	4	3	2

Figure 7. TOGAF EA and Business Skills (Opengroup.org, 2018)

The EA skills provided from TOGAF's classification will be used as the skills related to practice this EA approach. These skills will be used in conjunction with the other four EA approaches' related skills.

To conclude, TOGAF is an EA approach that mainly centres on improving an organisations' efficiency (Opengroup.org., 2018) and "*provides a focus for the design, planning, implementation and governance of an EA*" (Cabrera et al., 2015:113). TOGAF provides a clear methodology in its implementation that is accompanied by a framework that classifies the architecture according to business, application and technology layers. Furthermore, the Open Group has provided a detailed skill calcification for TOGAF that will be used as the related skills for this approach regarding the implementation of EA.

2.2.1.3. Federal Enterprise Architecture Framework (FEAF)

FEAF centres on providing standardisation between federal agencies to increase performance across these agencies (Federal CIO Council, 2013). FEAF focuses on six domains, namely, strategy, business, data, applications, infrastructure, and security. These domains provide the baseline that will be used to identify the skills required to implement this framework effectively. These domains will thus be used in conjunction with the Skills Framework for the Information Age (SFIA) (discussed later) to identify these skills.

FEAF emphasises the appropriate planning before changes can be implemented. The Collaborative Planning Methodology (CPM), as shown in *Figure 8,* is *"structured"* so that the architects can determine if any "models, experiences, and work products" can be reused from other organisations that have implemented these solutions beforehand (Okhrimenko, 2017:21). This highlights the importance that FEAF places on appropriate planning to consider reusable artefacts to streamline efforts and reduce unnecessary work.

The CPM is divided into two main components: *organise the plan* and *implement the plan* as shown in *Figure 8*. Within this classification, five subprocesses are identified: identify and add value, research and leverage, define and plan, invest and execute, and lastly, perform and measure. These subprocesses have specific activities that dictate how each process and stage should be carried out. FEAF states that although this methodology seems to be sequential in its execution, there are iterations between processes (Federal CIO Council, 2013).

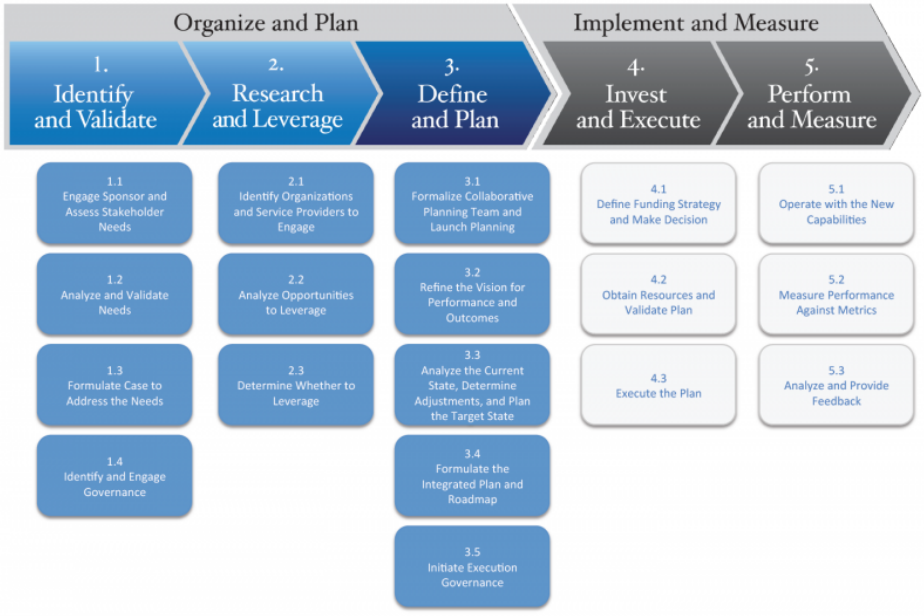


Figure 8. Collaborative Planning Methodology (CPM)

(Federal Enterprise architecture Framework Version 2,2013)

FEAF provides a precise list of deliverables needed at each of the previously identified domains. These deliverables are as follows in line with their provided hierarchy; Concept overview diagram, high-level process diagram, high-level logical data model, application interface diagram, high-level network diagram and lastly, a control list (Federal CIO Council, 2013).

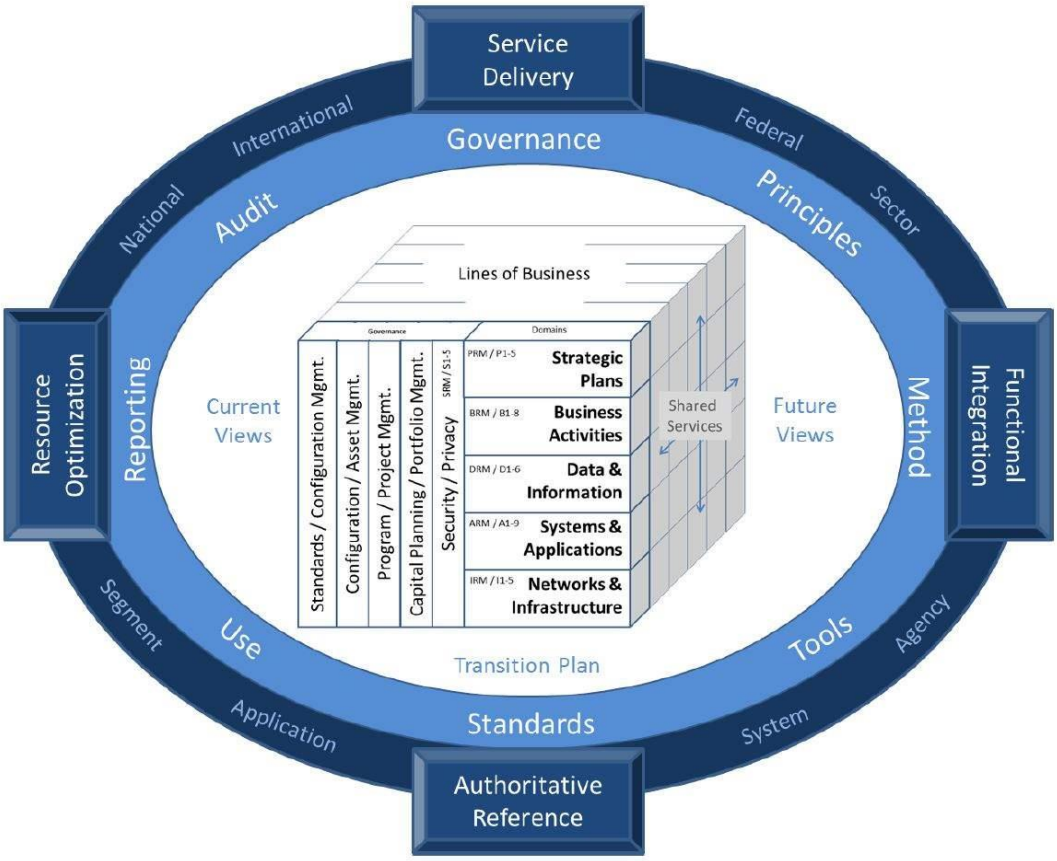


Figure 9. FEAF Domains (Federal Enterprise Architecture Framework Version 2,2013)

Figure 9 shows the FEAF framework. FEAF indicates the transition from a current architecture to a target architecture based on "*architecture drivers*" and the "*strategic vision*" (Goethals, 2005:12). The focus of this framework (for the study) will centre on the five domains identified and the core artefacts that the FEAF identifies for each domain. As this study focuses on the skills required to implement these EA frameworks, the technical processes will not be examined, but rather the outputs and focus areas of these frameworks, as they will be the most concise in providing guidelines for skill identification.

These artefacts highlight the importance of IT skills within this framework as they align with many design tools IT practitioners use. As FEAF emphasises these artefacts as the core ones needed in these domains, they provide a viewpoint in line with the importance of IT when the skills associated with this framework is identified.

In summary, FEAF emphasises planning and provides a planning methodology that dictates the EA process's execution (much like TOGAF's ADM). FEAF's focus is on five domains that subdivide the framework into logical areas. These domains have specific artefacts that need to be delivered and are identified within the framework's documentation

FEAF has a more specific use than the previously identified EAFs, and as stated by Ohren (2005), FEAF has limited usability outside US Government enterprises (Ohren, 2005), but as stated previously, FEAF is one of the four most used EAFs (Cameron & Mcmillan, 2010). Thus, the skills identified in this framework may provide different viewpoints that may not have been identified in the other more generically applicable models.

Although the framework has a specific focus, the required skills to implement FEAF may still prove valuable in identifying a generic skillset that theoretically need to serve specific EA frameworks and approaches as well as more generic ones.

2.2.1.4. Gartner Enterprise Architecture Process Model

According to Bittler and Kreizman (2005), EA is a process-driven discipline. They state that EA becomes synonymous within an organisation's decision making to execute its identified business strategies. They state that the Gartner EA process model was created from best practice research to establish this generic process model (Bittler & Kreizman, 2005).

The Gartner EA process model is shown in *Figure 10*. This process model shows how an EA process can be governed and implemented in an organisation. This model shows the process of an organisation employing EA and the actions that need to be taken. The model provides "key characteristics" and a "synthesis of best practices" for the creation of an EA (de Vries, 2010).

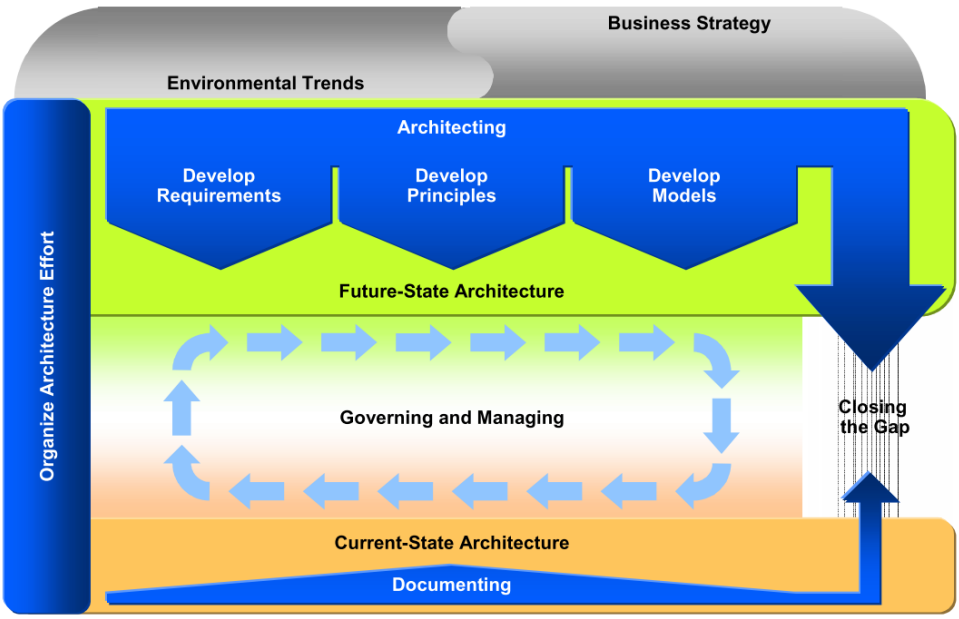


Figure 10. Gartner Enterprise architecture Process Model

(Bittler and Kreizman, 2005)

As stated by DePalo and Song (2012), the Garner process model focuses on the target architecture of the organisation rather than the current state, and once the target architecture has been identified, current implementations are "leveraged" to achieve the target architecture. (DePalo & Song, 2012). Referring to *Figure 10*, the process model can be described as follows: In developing an EA, the target or future architecture is identified. The current architecture is then used, where applicable, to achieve this goal as the future state is developed and documented. This future architecture is influenced by environmental trends and the organisation's business strategy. This entire process is managed and governed as shown in the centre of the model.

A key observation from Bittler and Kreizman (2005) is that the Gartner EA process model is non-linear and iterative (Bittler & Kreizman, 2005). Thus, the process model does not show a sequence of activities that need to be completed to design and implement an EA.

The Gartner EA process model is also well-suited to be used with other EA frameworks (Bittler & Kreizman, 2005). This adaptability means that the Gartner process model can be used with frameworks like the Zachman Enterprise Architecture framework to guide the processes in their implementation. This is worth noting because some frameworks, like the Zachman framework, do not provide a methodology for its implementation.

To conclude, "*EA is intended to bridge the gap between strategic planning and implementation efforts*" (Bittler & Kreizman, 2005:4) This again emphasises the importance of EA in organisations that employ the discipline. This process will naturally require the right skills to ensure that the process is implemented correctly and exclaims the need for a skillset that provides the EA practitioner with the required "tools" to support the process and implementation.

2.2.2. Enterprise Architecture Framework According to Domains

This section focuses on dividing the Enterprise Architecture frameworks (EAFs) as identified above into three distinct layers. The layers are identified through the ArchiMate framework as discussed previously, namely the *business layer*, the *data and application layer*, and lastly, *the technology layer*.

This division is done to determine whether these identified EA frameworks can be logically rearranged into these three classifications. The division will provide a basis of analysis when looking at skills to assign each EA framework. The segmentation of these EA layers will provide a more specific viewpoint for attaching the skills.

These three layers will identify the applicability of each EA Framework according to the Enterprise's business, data, and application, and lastly, technology architectures. From this classification, the skills assigned to these frameworks will also be grouped into these three domains, structuring the skills identified rather than having the skills only coupled to a specific EA framework.

The following subsections will divide the elements of each EA framework into the three identified layers where applicable.

2.2.2.1. Business Architecture

According to The Open Group, the business layer identifies business processes and services realised through business actors with the end goal of serving the customer. (Opengroup.org., 2017) Thus, the business layer can be seen as a high-level view of the organisation that describes how the products and services it provides to customers are realised through processes and business actors.

The first framework used is TOGAF. As identified in the previous section, TOGAF provides a content metamodel. This content metamodel provides its classification in the three identified EA layers. TOGAF provides three subsections within its business layer and specific elements per subsection. These subsections with their elements are as follows:

- Motivation–containing drivers, goals, objectives, measures
- Organisations–containing organisation units, locations, actions, and roles
- Functions–containing business services, contract service qualities, processes, events controls, procedures, and operations. (Opengroup.org., 2017)

The second framework that will be looked at is FEAF. For this study, the five domains of FEAF will be looked at for this classification. The domains that will be assigned to the business layer are the strategic plans domain and the business activities domain. (Federal Enterprise architecture Framework Version 2, 2013)

The third framework that will be looked at is the Zachman Framework. As stated previously, Zachman provided model names for his framework. Each of these names corresponds to a specific row and identify what artefacts are produced at each stage throughout the EA process. The rows that will be assigned to the t business layer, as identified by Zachman (2008), are the "scope and context (scope identification list)" and the "business concepts (business definition models)". (Zachman, 2008)

Lastly, Gartner's Enterprise Architecture process model will be reviewed. As stated previously, the Gartner process model is a generic model that can be used with other EA frameworks. (Bittler & Kreizman, 2005) Thus, the Gartner process model will be assigned to each architectural layer in totality. In other words, the process model identifies the processes used at each layer. This will not be repeated in the following two subsections at the risk of sounding redundant.

Thus, each of the identified frameworks can be classified in the container of a business layer. The specific sections of each framework that fit into the layer will be used to categorise the skills associated with each framework element. Thus, the skills identified for each business layer element that fits into this classification will also be classified under the broad umbrella of business layer centric skills. This classification will provide a different viewpoint on the identified skills on which analysis can be conducted.

2.2.2.2. Data and Application Architecture

According to The Open Group, the application layer depicts the applications and services used to support the organisation (Opengroup.org., 2017). Thus, the application layer can be seen as the supporting applications and their contained data used to provide the business services and products identified in the business layer.

As with the business layer, TOGAF provides an Information systems architecture that identifies the components that will be assigned to the data and application layer. TOGAF

content metamodel identifies “*Data entities*”, “*Logical data components*”, and “*Physical data components*” within its data structure and “Information system services”, “logical application components”, and lastly “, physical application components” within its application structure. (Opengroup.org, 2018)

Within the five architectural domains identified by FEAF, the “systems and applications” and “data and information” will be assigned to the application and data layers. The rows or model names identified by Zachman that will be assigned to the data and application layers are the “technology physics” row and the “System Logic” row (Zachman, 2008).

As with the business layer, the classification of frameworks into the data and application layer provides a way of classifying skills used when applying an EA in these areas.

2.2.2.3. Technology Architecture

The Open Group describes the technology layer as the physical infrastructure and technology services needed to operate the applications (Opengroup.org., 2017). Thus, the technology layer can be seen as the foundation on which the other layers build. Bringing all three layers together, the following can be identified; The business layer describes the process and services provided to customers through business actors. The application layer identifies the applications and data needed to provide the services and products as identified in the business layer. Lastly, the technology layer provides the infrastructure that the application layer needs to function. Thus, all three layers are interconnected and dependent on one another to ultimately provide a service/product to the customer.

The elements that will be assigned to the technology layer are “platform services”, “logical technology components” and lastly “physical technology components”. The domain of FEAF that will be assigned to the technology layer is the “networks and infrastructure” domain. The Zachman rows assigned to the technology layer are the “Tool Components” and Operations instances” rows.

As with the previous layers, the classification of frameworks within a technology layer provides a viewpoint of the skills that will be identified within this scope of application. Thus, the skills identified in the technology layer will be grouped according to the identification made above.

In conclusion, this section decomposed the identified EA frameworks’ components and elements into the classification of a business, application and data, and technology layer as identified through the ArchiMate framework. When the analysis of identified skills takes place, this classification will be used to group the identified skills into these different sections. This will provide a unique way of viewing the identified skills rather than only focusing on the skill

identification coupled to a framework. This allows the skills identified to be viewed independent of the framework derived from and to focus on the area (layer) where the skill(s) is applied.

2.3. Skill Classification

As stated on its website, the Skills Framework for the Information Age (SFIA) foundation is a non-profit organisation that focuses on developing and providing a skills framework for today's age. These skills are then categorised according to skills' overarching category and level of responsibility needed to master. SFIA works through iterations of their identified skills, thus updating skills as time passes and their importance becomes more pronounced. Currently, the SFIA framework is at version seven. The SFIA framework provides seven levels of responsibilities that are categorised by generic attributes (Sfia-online.org, 2019).

The main contribution of SFIA is providing skill categorisations that have subcategories and levels of responsibilities linked to each identified skill. This framework will be a valuable resource in the identification of the generalised skillset of EA. Depending on the EA framework being examined, the area the framework operates in, and the organisational need the framework aims to satisfy, the SFIA framework can be used to identify the associated skills that are linked to the EA framework.

For example. The SFIA framework can be used to identify the sub categorical information linked to the components identified in the previous section at each ArchiMate layer. This provides a baseline for the skill analysis/identification of an initial skillset that can be refined as the study progresses. The SFIA framework (as stated on their website) is a generic collection of skills (Sfia-online.org, 2019). This fits in well with the purpose of this study to define an optimal standardised skillset for EA practitioners. Thus, the use and identification of broad or generic skill classifications will provide a foundation for more specific skills to be assigned to (if applicable and necessary through evaluations and refinement).

Thus, the SFIA framework will be used for the initial representation of skills that have been identified through the analysis of the top four EA frameworks. The purpose of using SFIA is to provide a standardised naming convention for skills identified within the four EA frameworks examined in this study.

2.4. Conclusion

In the literature review section of this paper, the top four Enterprise Architecture (EA) frameworks were described; these frameworks were then (according to their components) divided into the classification of a business, application and data, and technology layers. This

section also discussed the classification or view that will be used alongside the analysis of skills in this paper.

The literature review provided insight into the different frameworks used in this study and identified the purpose and context that form the focus of each framework. TOGAF, FEAF, Gartner and the Zachman framework each provided a similar macro view of what an EA strives towards; the identification of a future framework and the implementation of the proposed architecture to fill the gaps between the current and proposed architecture.

The literature review also provided the identification of the skills classification that will be used. The main method of skill classification identified will be through the SFIA framework. The SFIA framework will support the identification of a proposed Skillset for EA and will be used as a reference when refining the Skillset throughout the research process.

To conclude, the literature review serves as a foundation for the study and a reference for the work that will be conducted. The literature review identified the focus areas of the research paper and helped identify the key aspects of the four examined EA frameworks.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Introduction

The research methodology section of this paper will explain what theory, paradigm, research strategy, data collection methods, data analysis methods and ethical concerns will be considered and used in carrying out the research. Furthermore, this section will also provide reasons for the various selections and explain how they fit into the research. This section will thus be broken up into the sections: research design, data generation and collection, data analysis and ethics.

The research design subsection will identify and explain the research theory, philosophy, paradigm, and strategy. The data generation and collection subsection will identify and describe how the data will be generated and collected (the technique), the process that will be followed to accomplish this (the plan), why this data is collected, and finally, how the data collected will be tested. The data analysis subsection will explain how the collected data will be analysed; thus, what analysis techniques will be used to work through the collected and generated data. Lastly, the ethical concerns that have a bearing on this paper will be looked at and discussed.

3.2. Research Design

The research design section will identify and explain the research philosophy/paradigm, theory, and strategy used in this paper. The research philosophy/paradigm used in this paper is pragmatism, the theory is soft systems methodology, and the research strategy is design science research. The following subsections will explain the reason for the selections in detail.

3.2.1. Research Philosophy / Paradigm

The purpose of stating the research philosophy/paradigm employed in this paper is to help identify how the researcher views the world. This view, in turn, will provide a foundation for the reader of the paper to interpret the information that follows.

Pragmatism is the identified paradigm/philosophy because it aligns with how the research will be carried out. Pragmatism provides a paradigm that focuses on both the aspects of positivism (often related to quantitative research and interpretivism (often related to qualitative research. Therefore, pragmatism takes both world views into account; the positivist world view, where knowledge is created independently of humans and interpretivism view, where knowledge's main foundation lies within the interpretations of human beings and their experiences. Thus,

pragmatism recognises that the world functions independently of human interactions, but these interactions provide meaning that translates to knowledge. Thus, according to Goles and Hischheim (2002), pragmatism recognises an “objective reality” that centres on the “environment and experiences of each individual” and the view that is taken is solely based on what will result in the “desired outcome” (Goles & Hirschheim, 2000:261) In other words, pragmatism employs the worldview that benefits this research the most.

Another way to frame the statement above is that pragmatism’s view is that the cause of a problem and the explanation thereof (through the research conducted) should be placed “closer to our values” because the “causal relationships” between them will never be fully understood (Teddlie & Tashakkori, 2009). This view means that although knowledge can be seen as “created in the world”, its true value is linked to a person's perceived value thereof.

Weber (2004) identifies several key differences between positivism and interpretivism. He identifies seven metatheoretical assumptions that classify both research philosophies and discuss the differences between the two. His analysis of the two research philosophies concludes that the differences between the two approaches lie within the methods used to carry out the research and not arbitrary differences between their underlying metatheoretical assumptions. (Weber, 2004)

This view provides another reason for employing pragmatism for this study as the research will make use of mixed methods and would thus not be suited for positivism or interpretivism as the methods used could limit the extent of the research. Many researchers that have employed pragmatism as their research philosophy have stated that it is the most suited paradigm for mixed-method research (Johnson & Onwuegbuzie, 2007). Thus, pragmatism also aligns with the way data will be analysed in this study and will not be bogged down to limitations that may be present in other paradigms.

Feilzer (2010) states that pragmatism aims at using the most appropriate research methods or approaches that will ultimately provide the best results for answering the research questions posed (Feilzer, 2010). This view aligns with the aim of this study that will use mixed methods research (MMR) as the best method of identifying the optimal standardised skillset for EA and evaluating and refining the skillset through qualitative data analysis in iterations present in design science research.

Lastly, pragmatism will be used in this study because of how the research can be carried out. As stated by Morgan (2014), most mixed-methods research focuses on answering the question of “how-to” where pragmatism emphasises the “why to”. (Morgan, 2014:2) This preference allows the researcher to focus on why these identified skills will improve the way

EA is implemented rather than stating possibilities of improving its implementation. In other words, pragmatism will allow the research to focus solely on identifying this skillset, emphasising why the identified skills will improve EA rather than how a specific skill might improve its implementation.

To conclude, pragmatism is the chosen philosophy/paradigm for this paper. Pragmatism will allow the research to focus on what methods work best to identify the proposed skillset for EA that will be aligned with the research strategy and theory employed.

3.2.2. Research Strategy

The research strategy that will be used in this study is design science research. Design science research is a research strategy that centres on creating and evaluating artefacts that aim to solve an identified organisational problem (Hevner et al., 2004). Thus, where other research strategies might centre on understanding the explanation of a phenomenon, design science research focuses on creating an artefact to solve an identified problem.

Hevner et al. (2004) provide guidelines for conducting design science research. These guidelines, summarised, state that design science research comes down to the creation of an artefact that solves the identified organisational problem. The artefact that is provided to solve the problem should be thoroughly evaluated through evaluation methods identified in the research. In addition, the artefact provided must show usable value beyond a reasonable doubt. The research is carried out through the appropriate application of methods that will identify areas of improvement through further evaluations to refine the artefact. Lastly, the result of the research should be presented so that the purpose of the research and the outcome of the Design Science Research (DSR) process can easily be understood (Hevner et al, 2004). The following paragraph describes the process to bring DSR into the view of this research paper.

The initial EA skills will be developed using quantitative analysis of the top four EA frameworks. This can be seen as the first iteration and artefact of this study. From this point forward, expert interviews will be held to evaluate the proposed skillset to refine it. This refining will be done and demonstrated in the research as required by the guidelines provided by Hevner et al. (2004) to ultimately present a skills framework that has been thoroughly evaluated and refined and that will ultimately provide a clear contribution that shows usable value for the field of EA and its practitioners.

3.2.3. Research Theory

The theory that will be used in this research is soft systems methodology (SSM). Soft systems methodology can be described as a theoretical approach suited for situations that are not well-defined and where a process is followed to understand and examine the problem so that the situation can be improved. (Reynolds & Holwell, 2010)

Checkland (2000) states that soft systems thinking is appropriate in research situations where the problem being investigated is not well defined, and the problem area is usually related to human use (Checkland, 2000). Therefore, it is appropriate in the context of this study as the skills identified for each EA approach are loosely defined. The appropriate application of these skills will ultimately lie within the ability of the EA practitioner.

Reynolds and Holwell (2010) use the original work of Checkland and Poulter (2006) to provide concise information about soft systems methodology. Their description of soft system methodology identifies the main approach used by Checkland and his colleagues. The four elements in the approach are: the identification and investigation of the problem, its components, and possible ways to improve it; the identification of activities that can be perused to improve the problem; the use of models developed as a basis to further improve the solution; and the combination of findings and results to ultimately create a feasible solution for the problem (Reynolds & Holwell, 2010).

This methodology also aligns with the purpose of this study to refine the initial set of identified EA practitioner skills and work through iterations as provided in DSR, ultimately to provide a refined skillset proposition for EA practitioners.

One way of emphasising why SSM will be the best-suited methodology for this study is to examine another considered theory. The other theory considered was the technology acceptance model (TAM) (Legris et al., 2001). It was concluded that the TAM model is an effective theoretical model when used to “understand and explain use behaviour in IS” (Legris et al., 2001:202). Although Legris and colleagues’ article highlights different variations of TAM, TAM depicts IT as an independent or standalone component within an organisation. This viewpoint conflicts with other studies within change management that identify the importance of technological implementations within organisations that influence their behaviour (Legris et al. l, 2001), and makes TAM unsuitable for this study.

Thus, TAM provides a single worldview that will not be suited for this study, as the identification and refinement of the proposed skillset will ultimately be based on the interdependence of EA within an organisation so that it can have an organisational effect rather than a departmental one, as previously mentioned in the problem statement of this paper (Drobik, 2002) .

To conclude, the theory that was chosen for this study is SSM as it aligns with the purpose of this study–to investigate the isolated skillsets that are present in the EA domain and work through a process of identification, classification, evaluation, and refinement to develop an optimal standardised skillset for EA practitioners.

3.3. Data Generation and Collection

This section explains the way the data was collected for the research. The data collection entailed the technique used in generating data from documents and collecting data from expert interviews. Furthermore, the data collection plan used to collect the data is shown to explain the process used to collect the data. Lastly, the pre-testing plan is shown to explain how the data was evaluated to ensure that it was fit for purpose.

This section describes how the data was generated and collected but does not contain the actual process. The process and results of the generation and collection of data can be found in Chapter 4 where the techniques described in this chapter are utilized. The aim of this section is to describe the methods used along with any considerations to provide guidance in the subsequent chapter where the methods are applied.

3.3.1. Data Generation Technique

The data generation technique will explain the way the data was acquired for the study. Oates (2006) identifies four main data generation methods: Interviews, observations, questionnaires, and documents. This study focused on using documents for data generation and expert interviews to validate the proposed skillset. The data generation through documents and refinement through expert interviews are detailed in chapter four.

As identified in chapter one, there are four leading EA frameworks. These frameworks are analysed to identify their required skills. This analysis generated the data that was used to identify an optimal standardised skillset for EA. The Skills Framework for the Information Age (SFIA) provided a framework to attach skills to a standardised naming convention. Thus, the data was generated through documents, namely the EA methods and frameworks documentation relating to the top four frameworks and categorised through the SFIA framework.

Once the proposed skillset had been identified, expert interviews were conducted to evaluate the proposed skillset and refine the skillset through cycles of the DSR. This was the second data generation and collection technique, where enterprise architect experts were interviewed to obtain information regarding the proposed skillset. The interviews were semi-structured to

allow participants to elaborate on certain aspects but were guided following predefined questions so that the interviews could stay focused on the required skills for practicing EA optimally.

To conclude, the first source of data was through the analysis of documentation relating to the top four EA frameworks and the second source of data used in this study (for evaluation and refinement purposes) was derived from interviews conducted with EA experts.

3.3.2. Data Collection Plan

The data collection plan aims at identifying a process that can be followed to collect the data. The data collection plan focused on two aspects: data collection through documentation and data collected through interviews. This section provides an overview of the planning process, that was applied in the actual data generation and collection as discussed in chapter 4.

3.3.2.1. Data Collection Plan for Documents

The top four EA frameworks were evaluated, and comparisons were made regarding the skill requirements identified within the application of each EA approach. The identified skills for the application of each framework were cross-compared to all the other frameworks to identify the recurrent nature of the skill. This provided a baseline of skills that could be used in the analysis. From this point on, the data analysis for the identified skills could take place, for example, assigning weights according to their prevalence. The main process for collecting the data from the documentation was as follows:

1. Identify core skill categorisations for each EAF
2. Identify skills for the linked core skill categories
3. Standardise the skills naming conventions
4. Cross compare skills of each framework and assign weights
5. Merge skillsets and remove skills with insufficient value
6. Group skills according to ArchiMate layers

The data collection plan as shown above is the starting point for the data generation in chapter 4. The plan identified above is expanded upon in chapter four, as the data generation is derived from the collection plan points identified. As the data generation execution is quite large the bulk of information containing the generation of data is found in chapter 4 where the plan is executed.

3.3.2.2. Data Collection Plan for Interviews

The data collected from expert interviews was used for evaluation and refinement purposes and was conducted after the initially standardised skillset for EA had been proposed. The interviews entailed EA experts evaluating the proposed skillset and providing feedback. The main process for collecting the data from interviews was as follows:

1. Identify the required outcomes of the interview process
2. Identify possible questions that can be asked
3. Conduct interviews
4. Format information so that it can be used for analysis and validation

The interview process, as shown in Chapter 4, consisted of providing the initial proposed skillset for evaluation. Participants were asked to comment on the ranking of skills, and to provide any other information regarding the skillset, for example missing skills. The interview process was held in isolation and participants were not able to view each other's comments and results to ensure that participant's evaluations did not influence each other.

Once an interview round was completed, the analysis of the data collected took place, and a new iteration was presented to the participants for evaluation. Median scoring on participant inputs were used to adjust the skillset. Participants were able to adjust the ranking of skills, and these inputs were used to identify a median score for each skill to adjust skills for the following iteration.

In cases where no consensus was reached for a skill using the median scoring technique, the adjustment mechanism was adapted to focus on the extent a participant argued in favour of a change. The reason this method was employed in these cases is to ensure that a rounded view of all skills was considered. The interview process also made use of rounds of interviews where participants could evaluate new iterations.

This means that if an argument and the subsequent placement of a skill was skewed, the participants had the option to adjust these skills once again until consensus was reached. After each round of interviews participants were provided with the newest skillset iteration and were informed about the changes made between the versions to ease the evaluation process. The interview process and results are discussed in chapter 4.

3.3.2.3. Overview of participants

This sub-section provides an overview of each participant's working experience. This provides a clear indication of each participants experience that contributed to this study. Each participant is listed below with a brief description of their working experience.

Participants are anonymous in this study; thus, they are identified according to a numeric classification:

- Participant #1
    - Started working in 2001 as a business analyst and moved over to EA for the remainder of the career
    - Certification in the Zachman Enterprise Architecture framework
- Participant #2
    - Working as an Enterprise Architect for the past 19 years.
    - Certifications have been obtained for TOGAF, the Zachman Enterprise Architecture Framework and Governance of IT
- Participant #3
    - Nine years of working experience as an Enterprise Architect
- Participant #4
    - PhD in information systems and strategic EA architecture
    - 18 years of experience.
- Participant #5
    - PhD in Conceptual Descriptions for EA
    - Has been teaching honours classes for EA for the past 14 years
- Participant #6
    - 14 years of experience in EA
- Participant #7
    - Started working in the EA field and a related field in 2005.
- Participant #8
    - Started as a software developer
    - Started working in EA field and a related field in 1990.

The participants of this study come from a wide range of industry sectors, stretching from university lecturers to practitioners in the banking, mining, nuclear engineering, and public enterprises sectors.

The participants provided a broad view of application areas for EA and the skillset required to practice the discipline effectively and efficiently. Each participant has been identified as an EA expert suited for the interviewing process, where the inputs received from participants are viewed in high regard based on their expert judgment in the field of EA.

The participants' inputs and feedback often echoed back to their current and past undertakings and provided a real-life evaluation of the skillset refined through life lessons learned through the implementation of EA principles in the working environments of these EA experts.

The participants of this study provided immense value from their expertise gained through the implementation of EA throughout their working careers. The evaluation and refinement process that ensued was aligned with these lessons learned to refine the skillset. It was based not only on participants' personal beliefs and opinions but also on past implementations and experience that have stood the test of time for these expert practitioners.

3.3.3. Testing

This section will focus on how the generated and gathered data was tested to ensure that it was fit for its purpose. Two areas were focused on: testing data gathered from documentation and data generated through the interviews.

The data gathered from the documentation was derived from the trustworthy EA framework documents. This data was then put through the data collection planning process as identified above to format the data to be analysed effectively and concisely. The formatted data was cross-examined concerning the other frameworks to ensure consistency in the data.

The interview questions used in the expert interviews were evaluated carefully to ensure that they would provide the correct data as a response. The data gathered from the interviews was checked where needed. Verification was obtained from participants to ensure that the responses given were correct. This verification was done by confirming statements made in the interviews with participants before noting them down, to ensure that the correct meaning was captured from participant's statements whilst conducting the interviews.

3.4. Data Analysis

The research made use of both quantitative and qualitative data analysis. Thus, the data analysis was done through mixed methods research. Johnson and Onwuegbuzie (2007) stated that MMR should be used in situations where the use of mixed methods research is "*likely to provide superior research findings and outcomes*". (Johnson & Onwuegbuzie, 2007:129)

MMR was applied in the following way to describe the analytical tools used. The initial skillset was developed through quantitative data analysis. This process is described in detail throughout chapter 4 where the analysis took place. Broadly, the process entailed datamining selected EA literature to identify themes within the literature through the tokenization of words.

The chapter then works through a process of linking identified themes to categories and sub-categories of SFIA. From this point forward the skills are cross compared to identify a ranking for the initial skillset.

When moving over to the interviews a mix of quantitative and qualitative data analysis was employed. As stated in section 3.3.2.2, the inputs acquired from participants were measured through median scoring of rankings provided to each skill. In cases where no consensus was formed around a specific skill, qualitative data analysis was used, where the participant's argument was considered to allocate the skill to a ranking.

Another reason for using mixed methods research is that both qualitative and quantitative research have specific advantages and disadvantages, summarised by Oates (2006) as depicted in Table 1 and Table 2.

The advantages and disadvantages stated in the tables indicate how each data analysis method can bring value to the research. Using both methods aim to provide a well-rounded view of the proposed skillset by focusing on numeric and qualitative data to identify required skills, substantiate the skills identified, evaluate their relevance, and refine the skillset.

The data gathered from the documentation was cross-references and compared to each other. This gave a numeric value to the prevalence of skills within each framework. This data could then be assigned weights for further analysis. The reason quantitative data analysis was used is that it is well suited for the task at hand, i.e., rating and ranking the skills required for EA as a discipline. The main outcome is a skillset derived from ratings and rankings assigned to skills in each skillset to identify the importance and impact of each skill.

Table 1: Quantitative Advantages and Disadvantages.

Advantages	Disadvantages
There is a perception in the academic community that quantitative analysis is the only reliable data analysis technique.	People generally don't find numbers interesting. This causes a challenge in presenting the data so that people may find it more interesting to read.
The data can be analysed through tried and tested methods that have been used many times.	There is a possibility that a researcher "goes down the rabbit hole" and does unnecessary calculations that have no bearing on the question at hand.
The data used is not subjected to a person's reasoning but is rather measurable units of data.	There are prescribed ways of doing data analysis, and the preparation and execution should be well defined and in line with the method used.
Technology has enabled the processing of copious quantities of data relatively fast and easily.	Certain variables used in equations may be interpreted or applied incorrectly by the researcher, causing inaccurate results.

Adapted from Oates (2006)

Table 2: Qualitative Advantages and Disadvantages

Advantages	Disadvantages
The available data to analyse is plentiful and vast compared to analysis solely based on numbers.	The vast amounts of data might impair the researcher due to the volume of possible data.
The analysis of data may only be a single interpretation out of multiple possibilities.	The analysis of the data is subjected to the interpretations of the researcher rather than the data itself.
	Unstructured data can be cumbersome to include in research papers.

Adapted from Oates (2006)

Qualitative data analysis will be used in the expert interviews to evaluate and refine the proposed skillset. The interview transcripts will provide feedback and remarks that will be used to analyse the perceived relevance and importance of the proposed skillset.

In the case of the quantitative data, the themes identified within the EA frameworks will form the baseline for quantitative analysis, like assigning weights and correlating the identified

skills. Braun and Clarke (2012) identified a six-phase approach to conducting thematic analysis. These phases summarized are to thoroughly understand the data with which you are working. This entails working through the data to understand what the data means and what it assumes. Secondly, develop codes for the identification of themes. The researcher can then work through the data and identity possible themes. Once these themes have been identified, evaluate the themes to ensure that all identified themes are unique and not redundant and that there are meanings within the themes identified. The last phase is the creation of the research paper or report where the analysis and information brought forth from the thematic analysis should be displayed. (Braun & Clarke, 2012)

The research will use both quantitative and qualitative data to provide a well-rounded view of the proposed skillset and its acceptance.

3.5. Ethics

The following section will explain all ethical considerations related to the research undertaken. The rights of the participants are discussed concerning the interviews conducted while the underlying responsibilities of the researcher are also be explained.

3.5.1. Rights of Participants

The rights of participants and the ethical considerations that were taken into account during the research, as identified Oates (2006), are shown in Table 3 in tabular form.

Table 3: Ethical Considerations

Right of participant	Explanation
Decline participation	The participant has the right to choose if they want to be involved in the research.
Withdrawal	The participant can at any time withdraw their participation in the research. In such a case, the participant will not be included in the research and all gathered information for the participant will be removed.
Informed Consent	The participant should be provided all the required and necessary information regarding their involvement in the research and the purpose of the research
Anonymity	The participant has the right to anonymity; thus, no identifiers should be included in the study that can relate to the participant.
Confidentiality	The participant has the right to hold information confidential if he/she specifies. This means that the information that has been made confidential should not be present in the research.

Adapted from Oates (2006)

The rights of participants, as identified above, entail the main ethical considerations that had to be considered in the research. The research participants were fully aware of their rights and were allowed to exercise their rights, and the research was conducted ethically in line with these rights.

3.5.2. Responsibilities of an Ethical Researcher

The responsibilities of an ethical researcher relevant to this study, as stated by Oates (2006), were at all times considered and upheld by the researcher: The researcher abstained from gathering information that was not relevant to the research, “behave[d] with integrity”, acted appropriately according to the setting and abstained from plagiarism (Oates, 2006).

Thus, information like the participant's name, age and income were not presented in the research as there was no reason to include such information. The information gathered solely focused on pertinent information necessary to answer the research questions. Furthermore, interviews were conducted professionally with the interest of the participants held in high regard and lastly, the information obtained was cited according to the author of the statements.

3.6. Conclusion

The research methodology section provided the necessary information that acted as a foundation for the research carried out. In conclusion, pragmatism was identified as the chosen philosophy/paradigm for the research to be carried out, DSR was chosen as the research strategy and the research theory chosen was SSM.

This chapter identified that documents will be used as the data generation technique to develop the initial skillset iteration and that expert interviews will be conducted to refine the skillset. This chapter also described the data collection plan for both the data generation through documents and the process used to collect data from interviews. The way testing was conducted on the data and the way the data was analysed is also described in this chapter. Lastly, ethical considerations were looked at in this chapter to ensure that the research was carried out in an ethical manner.

CHAPTER 4: ANALYSIS, DISCUSSION AND RESULTS

4.1. Introduction

This section of the thesis covers the analysis of the top four EA frameworks and the subsequent interviews that will be held, the discussion of the identified skillset through this analysis and finally, the results of the process.

As discussed earlier in this paper, the analysis will start with the top four EA frameworks. Each framework will be looked at individually to identify the core skills associated with each. This review will be done through the data generation plan provided in Chapter 3. Once an initial skillset had been identified through this evaluation, interviews were held with EA experts. These interviews entailed working through the DSR process, iterating through the evaluations gathered during the interviews until an artefact could be presented that fitted the aim of the research; to provide an optimal standardised skillset for practitioners of the EA discipline.

To conclude, this section of the paper will focus on identifying and explaining the skillset and the process that was followed to achieve the result. All considerations, processes and workflows will be explained in detail in each section to precisely identify what analysis took place and how the skillset was developed. This will ensure that the research is well documented and thoroughly explain the process to substantiate the conclusions.

4.2. Data Generation

This sub-section will focus on data generation through the analysis of the top four EA frameworks. This sub-section will include an explanation of the process to identify how the data was analysed and used to create an initial skillset. Once an overview of the process is provided, the analysis of the frameworks will take place. The result of this sub-section is the provision of an initial skillset used in the expert interviews to evaluate and refine the skillset until it was satisfactory for the research purpose.

4.2.1. Explanation of Data Generation Process

The data generation through documents is explained in the steps below. These steps are derived from the plan developed in Chapter 3. It is worth noting that each framework will be isolated in the analysis until step four is reached. The steps with their explanations are as follows:

1. Identify core skill categorisations for each EAF
2. Identify sub-skills for the linked core skills
3. Standardise the naming conventions of identified skills
4. Cross compare skills of each framework and assign weights to each skill
5. Merge skillsets and remove skills with insufficient value
6. Group skills according to the ArchiMate layers
7. Closing remarks on the initial skillset that will be used in interviews

Step 1: This step entails identifying core skill categorisations within each of the top four EA frameworks. This step centres on the identification of these core skill categorisations through the literature review provided and text mining performed on the framework manuals and papers.

This step provides an overview of overarching skill categorisations and themes within each of the EA frameworks. The SFIA framework will be used to identify overarching core and sub-skill categories on which to base the themes identified and provide a standardised naming convention. Thus, this step entails the identification of core skill categorisations within the SFIA framework for each of the EAFs to provide a starting point where these SFIA skills can then be assigned to the frameworks.

Step 2: Once the overarching skill categories of each framework has been identified, SFIA is used to assign skills to each overarching skill category. These skills identified through SFIA form the eventual skills proposed in this paper. Thus, the overarching skill categorisation identified through step one will guide the specific selection of skills in this step.

Step 3: This step will focus on standardising the skillsets so that they can be compared. The Open Group Architectural Framework (TOGAF) skills framework will be standardised to fit the naming conventions of the SFIA framework where the skills are linked.

Step 4: The isolated and standardised lists are cross-compared with each other in this step to identify the relevance of each skill. This step will show the importance of each skill through its inclusion in the other frameworks.

Once the skills have been compared, weights will be assigned to each skill to identify its relative importance compared to the other skills in each framework. This step forms the foundation of what skills will be included in the initial skillset.

Step 5: This step entails merging the skillsets into one list with the calculated weights of each skill. This step provides the initial form of the skillset that will still be refined before it is used in

the interviews. All skills that show a value too insignificant to be included were removed at this step to keep the skillset focused on the most important skills and not overly inclusive.

The skills are also assigned a rank according to the number of occurrences across the EA frameworks.

Step 6: The ArchiMate layers discussed in the literature review are used to group the skills into this three-level classification. The literature review has shown how each framework fits into the ArchiMate framework, and this basis was used to subdivide the skills.

Step 7: This step is a formality to finalize the initial skillset and conclude the process. This will provide an opportunity to reflect on the selection and make comments about the initial skillset used in the following expert interviews.

Figure 11 identifies how the EA manuals and papers were text mined:

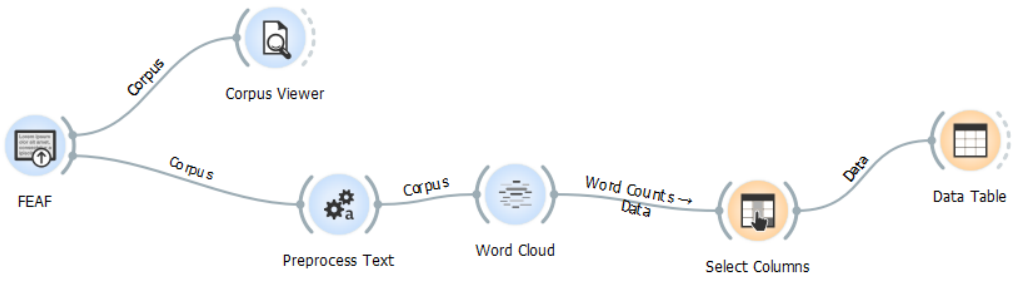


Figure 11. Text Mining Process

4.2.2. Data Generation Through the Data Generation Plan

The data generated from the top four EA frameworks followed the steps provided in the previous subsection. This subsection entails working through each of these steps to provide an initial skillset that will be evaluated and refined through iterations, with feedback provided from the expert interviews.

4.2.2.1. Step 1: Identify core skill categorisations for each EAF

This subsection provides the identification of skill categorisations for each of the top four EA frameworks. The categorisations for each EA framework are derived through two methods: through text mining performed on the EA frameworks' manuals and papers and, secondly, through incorporating the literature review and the concepts identified within each of the EA frameworks. The categorisations identified in this step provide a starting point where skills can then be allocated to the categories identified. The purpose of this sub-section is to identify

these categories for each of the four EAFs to enable the use of SFIA to assign skills and standardise the naming conventions of these skills.

The text mining process follows the process as shown in Figure 11. The process results in tokenised words for each framework. Stop words were filtered out and the result of this process provides the themes identified for each EAF as identified in the following subsections. The ranking of these themes is based on the number of occurrences of the tokenized words resulting from the text mining process.

The core themes are linked to the SFIA framework so that naming can be standardised, and sub-skills can be added to the overarching identifications. Each of the EAFs are disused below and how the core themes were identified and linked to main and sub-categories of the SFIA framework. The main SFIA skill categories are described as "core" skill categories and the underlying sub-categories are described as sub-categories in the following sections.

a. The Zachman Framework for Enterprise Architecture

The following two documents were text mined and analysed to identify core themes and skills for the Zachman framework:

1. "*Extending and formalizing the framework for information systems architecture*" by Sowa and Zachman (2010).
2. "*A Framework for information systems architecture*" by Zachman (1999)

The following top themes with their ranking were identified through the text mining process: "systems" (1), "model" (2), "information" (3), "business" (4) and "data" (5).

Another basis for identifying core concepts in the Zachman framework is the model names that are mentioned in the literature review: "*Scope Contexts*", "*Business Concepts*", "*System Logic*", "*Technology Physics*", "*Tool Components*" and lastly "*Operations Instances*" (Zachman, 2008).

These model names can be used as a guideline to identify core concepts associated with the Zachman framework alongside the text mining results generated. The model names centre on two broad concepts, namely business and information technology. This statement is substantiated with the text mining results that also show the same themes; thus, information technology as "*systems*" (1), "*model*" (2), "*information*" (3) and "*data*" (5) and secondly business as "*business"* (4). Although the "business" theme was identified as the second rank, the information technology themes were more pertinent.

The first core skill category of SFIA used to assign skills to the Zachman Framework is “Strategy and architecture”. This skill category and the identified sub-categories are assigned first because Zachman assigns the boundaries of an enterprise to where the framework is to be applied; to the business assets and functions that contribute to an organisation’s mission and/or set of objectives (Zachman, 1997). This approach aligns with the need to develop a strategy to implement the architecture to contribute to the organisation's mission and objectives.

The second reason is that the sub-categories of “*Information Strategy*”, “*Business Strategy and Planning*” and “*Technical Strategy and Planning*” fit the model descriptions of “*Business Concepts*”, “*Systems Logic*” and “*Technology Parts*” as well as the themes identified through the text mining process.

The second core skill category of SFIA that is linked with the Zachman framework is “Development and Implementation”. This category is linked because at the core of the Zachman framework is the translation of a complex problem into an easy-to-use, apply and understand model. Thus, as stated in the literature review, the Zachman framework provides a way to categories complex objects into different viewpoints and perspectives that provide a simplified classification of the overall structure (Zachman, 1997). This categorisation facilitates developing the necessary components to serve the organisation’s mission and objective. This statement is also substantiated through the “systems” (1) and “model” (2) themes identified in the text mining that show the relevance of these concepts within the documentation.

In conclusion, the core skill categories and sub-categories identified for the Zachman Framework from the SIFA categories and sub-categories are:

1. Strategy and architecture
    a. Information strategy
    b. Business strategy and planning
    c. Technical strategy and planning
2. Development and implementation
    a. Systems development

b. The Open Group Architectural Framework

The following document was text mined and analysed to identify core themes for TOGAF:

1. *TOGAF Version 9* by The Open Group (2009).

The following top themes with their ranking were identified through the text mining process: “business” (1), “data” (2), “information” (3), “services” (4), “application” (5), and “management” (6).

The literature review highlights three areas where core themes can be linked to TOGAF. These are the ArchiMate layers, TOGAF methodology and lastly, the skills classification of TOGAF. Although TOGAF provides a skills classification, the core themes of TOGAF will still be identified to provide an alternative viewpoint of the framework.

Firstly, the three architectural layers of ArchiMate are the business layer, the data and application layer, and the technology layer. These layers provide three distinct focus points of the framework. These three layers help identify core themes of TOGAF and will be used to associate skills through the SFIA Framework and TOGAF skills framework. This linkage is substantiated through the themes identified in the text mining process that are as follows: Business layer as “business” (1), application layer as “data” (2), “information” (3), “application” (5) and technology layer as “services” (4).

TOGAF also provides a methodology for its implementation. The main theme that can be identified in this methodology is that it all centres on requirements management at the centre of the model. This linkage is substantiated by the text mining process that shows “management” (6) as a core theme.

Thus, the core themes are as follows: Business, applications, and technology (As identified through the ArchiMate layers) and requirements management. The following core themes are identified and will be assigned to TOGAF to synthesise these themes into more generic ones: Business, IT and Management.

The Open Group provides its skills classification. Their skills classification will be cross-compared with skills fitting the ones in the SFIA classification so that the skills that are being measured are the same.

The skill categories, within the TOGAF skills framework, in line with the core themes identified for TOGAF (Opengroup.org., 2018) are as follows:

1. Business skills and methods
2. Enterprise architecture skills
3. Program or project management skills
4. IT general knowledge skills
5. Technical IT skills

The skills within these categories will be cross-compared with the entire skills classification provided by SFIA where the skills will be standardised. This will allow the skills classification provided by TOGAF to be aligned with the skills provided by SFIA, guided by the core themes that were identified.

c. Federal Enterprise Architecture Framework

The following document was text mined and analysed to identify core themes and skills for FEAF:

1. "*Federal Enterprise Architecture Framework Version 2*" by the federal government of the United States. [Online].

The following top themes with their ranking were identified through the text mining process: "data" (1), "business" (2), "information" (3), "security" (4), "management" (5), "planning" (6)

FEAF is a specific framework developed for federal use with a key focus on standardisation between federal agencies (Federal CIO Council, 2013). The core themes as identified in the literature review is that FEAF centres on six domains, namely: Strategy, business, data, applications, infrastructure and security.

These domains correlate strongly with the themes identified in TOGAF and the Zachman framework. As with the previous two frameworks, there is an emphasis placed on IT and business domains.

Another observation made in the literature review is that FEAF follows a sequential process but with iterations throughout its application. This process contrasts with TOGAF that, although iterative, does not follow a prescribed sequence in its application. The core themes for FEAF are the six domains on which the framework is centred.

The first core skill category of SFIA that is linked to FEAF is "*Strategy and architecture*". This category is chosen because it links strategy, business, data, and applications provided in the six domains. This linkage is substantiated with the results of the text mining showing the following themes–strategy as "planning" (6), business as "business" (2), data as "data" (1) application as "information" (3).

The SFIA subcategory of "Information strategy", within the core skill category of "*Strategy and architecture,*" fits this classification as its skills align with data-centred skills. This linkage is substantiated with the results of the text mining showing the themes of "data" (1) and "information" (3)

The SFIA subcategory of “business strategy and planning”, within the core skill category of “*Strategy and architecture,*” fits this classification because its skills fit with the business domain and the text mining results of “business” (2) and “planning” (6).

Lastly, the “technical strategy and planning” SFIA sub-category, within the core skill category of “*Strategy and architecture,*” fits this classification because its skills align with the application domain. This category centres on strategy and architecture that fits the domain of strategy, and the text mining results of “planning” (6) and “data” (1).

The second core skill category of SFIA linked is “*change and transformation*” with the two sub-categories of “business change implementation” and “business change management”. This linkage is made because it correlates with the domains of “strategy” and “business” as well as with the text mining themes of “business” (2), “management” (5) and “planning” (6)

The third core Skill category of SFIA that is linked to FEAF is “*development and implementation*”. The reason this category is chosen is that the skills within the sub-category of “systems development” align with the domains of infrastructure and security and link with the text mining themes of “information” (3) and “security” (4).

Thus, the core skill categories and sub-categories identified for FEAF from the categories and sub-categories of SFIA are as follows:

1. Strategy and architecture
    a. Information strategy
    b. Business strategy and planning
    c. Technical strategy and planning
2. Change and transformation
    a. Business change implementation
    b. Business change management
3. Development and implementation
    a. Systems development

d. Gartner

The document “*Gartner Enterprise architecture Process: Evolution October 2005*” was text mined and analysed to identify core themes for the Gartner Framework (Bittler & Kreizman, 2005).

The following top themes with their ranking were identified through the text mining process: “process” (1), “business” (2), “model” (3), “strategy” (4), “future” (5)

The Gartner Enterprise Architecture process model is a generic model created from best practice research (Bittler & Kreizman, 2005). Unlike the other EA frameworks provided in this study, Gartner provides a process model to guide the implementation of EA rather than adhering to a framework.

The Gartner process model, like TOGAF methodology, is non-sequential and iterative. But unlike TOGAF methodology, the Gartner process model is a generic model that can be used with different EA Frameworks. This statement does not mean that TOGAF cannot be used with other frameworks, for example, the Zachman framework, but Gartner provides a more generic model where TOGAF model is more aligned with its framework.

At the centre of the Gartner process model lies governance and management that keeps the model in check. The main driving factors for the model and the ultimate core themes used are the business strategy, environmental trends, and governance that dictate the implementation and adaptability of the Gartner process model. These three domains are the core themes identified for the Gartner process model that will be used in the steps to follow.

The first core skill category of SFIA that will link the Gartner process model to SFIA is "*Strategy and Architecture*". Strategy and Architecture are linked to Gartner because the emphasis the Gartner process model places on governance, and the skills that SFIA assign to the sub-category of "Information Strategy" aligns with this focus point. Governance forms the centre of the process model and shows the importance of managing the implementation of business functions. Another reason why this category is chosen is because of the direct link between the categories "Business strategy and planning" and Gartner's emphasis on business strategy as one of the overarching driving forces of the model, alongside environmental trends. These links are substantiated by the text mining themes of "business" (2) and "strategy" (4).

The second core skill category of SFIA that will be linked to the Gartner process model is "Change and Transformation". This category is linked because of the emphasis the Gartner process model places on environmental trends as one of the overarching driving forces of the model and thus highlighting the importance of having the ability to implement and manage change when environmental trends shift the focus of an organisation's objectives. The text-mining results identify the theme of "future" (5) and highlight the model's characteristic of closing the gaps, providing a solution in a future implementation, and being adaptive and flexible to changes that influence the process.

The text mining themes of "process" (1) and "model" (3) were not singled out in the linkage because these two themes identify the essence of the Gartner model, as it provides a process for implementing an architecture. These themes were also not filtered out because they show

the model emphasises the process being followed, which aims to fill the gaps identified to provide an improved target architecture.

To conclude, the core skill categories and sub-categories linked to the Gartner process model are:

1. Strategy and Architecture
    a. Information Strategy
    b. Business Strategy
2. Change and Transformation
    a. Business Change Implementation
    b. Business Change Management

e. Summary

The core skill categories and sub-categories for each of the EA frameworks being analysed were identified in this sub-section. This sub-section is regarded as a starting point for the analysis and does not reflect the result of the proposed EA skillset. Linkages were made between the EA frameworks and core themes to provide a baseline where more detailed analysis can follow.

Themes were identified through two means, namely, a text mining process conducted on EA framework-specific documents and a thorough analysis of the literature review. These two methods provide a way to link the themes of these frameworks to the standardized skills framework that SFIA provides. The results of the analysis are by no means a concrete representation of the skills required for each of the EA frameworks. The results provide a starting point that is needed to continue analysis. Thus, the results provided should not be regarded as refined conclusions but rather just as a starting point where the core skill categories and sub-categories of SFIA that were linked to each of the EA frameworks can be used to assign specific skills that will then be evaluated through expert interviews.

Thus, this step provides the first linkage between each of the EA frameworks and a standardized skillset. From this point forward, more specific skills can be added to the overall skill framework and be refined through iterations to evolve from a linkage of core themes to an initially proposed skillset that encompasses all four EA frameworks.

4.2.2.2. Step 2: Identify skills for the linked core skill categories

a. Introduction

This sub-section entails providing a list of skills from SFIA in line with the core skill categories identified in the previous step. The skills for each of the categories identified in the previous step will be listed under each EA framework. The exception will be TOGAF as this framework's skillset will be cross-referenced with the SFIA skillset instead of SFIA categories. These skills form the detailed skillset for each framework and will be refined in the following steps to be eventually used in the subsequent expert interviews.

b. The Zachman Framework for Enterprise architecture

The core and sub-skill categories identified for the Zachman framework are:

1. Strategy and architecture
    a. Information Strategy
    b. Business Strategy and Planning
    c. Technical Strategy and Planning
2. Development and Implementation
    a. Systems Development

The skills of SFIA that fall into these categories are depicted in Table 4.

Table 4: SFIA skills for Zachman

Category/Sub-Category	Skills
1. Strategy and architecture	
a. Information Strategy	Enterprise IT Governance, Strategic Planning, Information Governance, Information Systems Coordination, Information Security, Information Assurance, Analytics, Data Visualization, Information Content Publishing
b. Business Strategy and Planning	Demand Management, IT Management, Financial Management, Innovation, Research, Business Process Improvement, Knowledge Management, Enterprise and Business Architecture, Business Risk Management, Sustainability
c. Technical Strategy and Planning	Emerging Technology Monitoring, Continuity Management, Network Planning, Solution Architecture, Data Management, Methods and Tools
2. Development and Implementation	
a. Systems Development	Systems Development Management, Systems Design, Software Design, Programming/Software Development, Real-time/Embedded Systems Development, Animation Development, Database Design, Network Design, Testing, Safety Engineering, Information content Authoring

c. The Open Group Architectural Framework

The core skill categories identified for TOGAF are:

1. Business Skills and Methods
2. Enterprise Architecture Skills
3. Programme or Project Management Skills
4. IT General Knowledge Skills
5. Technical IT Skills

These core skill categories are referencing the ones provided by the Open Group. These core skill categories will be used to list the skills that the Open Group provides.

The skills for TOGAF that fall into this classification are depicted in Table 5.

Table 5: TOGAF skills

Category / sub-Category	Skills
1. Business Skills and Methods	Business Case, Business Scenarios, Organisation, Business Process, Strategic Planning, Budget Management, Visioning, Business Metrics, Business Culture, Legacy Investments, Business Functions
2. Enterprise architecture Skills	Business Modelling, Business Process Design, Role Design, Organisation Design, Data Design, Application Design, Systems Integration, IT Industry Standards, Services Design, Architecture Principles Design, Architecture Views and Viewpoints Design, Building Block Design, Solutions Modelling, Benefits Analysis, Business-inter Working, Systems Behaviour, Project Management
3. Program or Project Management Skills	Programme Management, Project Management, Managing Business Change, Change Management, Value Management
4. IT General Knowledge Skills	IT Application Development Methodologies and Tools, Programming Languages, Brokering Applications, Information Consumer Applications, Information Provider Applications, Storage Management, Networks, Web-Based Services, IT Infrastructure, Asset Management, Service Level Agreements, Systems, COTS, Enterprise Continuums, Migration Planning, Management Utilities, Infrastructure
5. Technical IT Skills	Software Engineering, Security, Systems and Network Management, Transaction Processing, Location and Directory, User Interface, international Operations, Data Interchange, Data Management, Graphics and Images, Operating Systems Services, Network Services, Communications Infrastructure

d. Federated Enterprise Architecture Framework

The core and sub-skill categories identified for FEAF are:

1. Strategy and Architecture
    a. Information Strategy
    b. Business Strategy and Planning
    c. Technical Strategy and Planning
2. Development and Implementation
    a. Systems Development

The skills of SFIA that fall into these categories are depicted in Table 6

Table 6: SFIA skills for FEAF

Category/Sub-Category	Skills
1. Strategy and Architecture	
a. a. Information Strategy	Enterprise IT Governance, Strategic Planning, Information Governance, Information Systems Coordination, Information Security, Information Assurance, Analytics, Data Visualization, Information Content Publishing
b. Business Strategy and Planning	Demand Management, IT Management, Financial Management, Innovation, Research, Business Process Improvement, Knowledge Management, Enterprise and Business Architecture, Business Risk Management, Sustainability
c. Technical Strategy and Planning	Emerging Technology Monitoring, Continuity Management, Network Planning, Solution Architecture, Data Management, Methods and Tools
2. Change and Transformation	
a. Business Change Implementation	Portfolio management, Programme management, Project management, Portfolio, Programme, and project support
b. Business Change Management	Business Analysis, Business Modelling, Requirement's Definition Management, Organisational Capability Development, Organisation Design and Implementation, Change Implementation Planning and Management, Business Process Testing, Benefits Management
3. Development and Implementation	
a. Systems Development	Systems Development Management, Systems Design, Software Design, Programming/Software Development, Real-Time/Embedded Systems Development, Animation Development, Database Design, Network Design, Testing, Safety Engineering, Information Content Authoring

e. Gartner Enterprise Architecture

The core and sub-skill categories identified for Gartner are the following:

1. Strategy and Architecture
    a. Information Strategy
    b. Business Strategy
2. Change and Transformation
    a. Business Change Implementation
    b. Business Change Management

The skills of SFIA that fall into these categories are depicted in Table 7

Table 7: SFIA skills for Gartner

Category / sub-Category	Sub-Skills
1. Strategy and Architecture	
a. Information Strategy	Enterprise IT Governance, Strategic Planning, Information Governance, Information Systems Coordination, Information Security, Information Assurance, Analytics, Data Visualization, Information Content Publishing
b. Business Strategy and Planning	Demand Management, IT Management, Financial Management, Innovation, Research, Business Process Improvement, Knowledge Management, Enterprise and Business Architecture, Business Risk Management, Sustainability
2. Change and Transformation	
c. Business Change Implementation	Portfolio Management, Programme Management, Project Management, Portfolio, Programme and Project Support
d. Business Change Management	Business Analysis, Business Modelling, Requirements Definition and Management, Organisation Capability Development, Organisation Design and Implementation, Change Implementation Planning and Management, Business Process Testing, Benefits Management

f. Summary

This sub-section entailed the assignment of skills to each of the EA frameworks. These skills will form the mix of skills proposed as an initial skillset for this study. The following steps will work towards refining these identified skills to be used in the interviews to follow. All skills

were derived from the SFIA framework except the skills identified for TOGAF. These skills will be cross-referenced and compared to the entire skill list of SFIA to standardize the naming conventions.

4.2.2.3. Step 3: Standardize Naming Conventions

This step entails standardizing the naming conventions of TOGAF skills framework in relation to the SFIA framework. The identified skills of TOGAF within their skill offering will be compared with the skills available in SFIA. The SFIA skills will then be linked to TOGAF skills (where possible) to align the skills of TOGAF with the SFIA skills used for the remainder of the EA frameworks.

When there is a connection between an SFIA skill and more than one TOGAF skill, they are assigned multiple times. This will ensure that any possible connection between naming conventions is included within the standardized list. The number of times an SFIA skill is assigned to one or more TOGAF skills will not be considered. The outcome of this process is to identify the inclusion of SFIA skills within TOGAF skill framework. In other words, the aim is to identify the linkage between skill sets so that the standardized TOGAF (through SFIA) skillset can be compared with the rest of the EA framework's derived skillsets.

The result of this process is shown in the appendix under "Standardized naming conventions". All the identified TOFAG skills could be linked to one or more SFIA skills, except in the case of "Business Culture" and "Legacy Investments", as shown in the results. These two skills will not be included as core skills for TOGAF in the remainder of the study as no significant reason to include them was established, and no noteworthy focus of these two skills was found in the rest of the EA frameworks. Furthermore, if these skills were to be regarded as important, this would have become apparent during the expert interviews conducted on the initial skillset. Thus, these skills will not be included forward.

4.2.2.4. Step 4: Cross compare skills of each framework and assign weights

This section entails cross comparing the identified SFIA skills for each framework. The purpose of this section is to create a list of all the skills included within the EA frameworks and assign a weight to each skill according to the number of times it is included across all frameworks.

Skills linked to a framework are assigned a "1", and skills not assigned to a framework a "0". Once all the skills have been numbered, the inclusion of skills within a framework are counted. This process provides a list of all the SFIA skills with the number of inclusions per EA framework. The results of this cross-comparison can be found in the appendix under "Skill Cross-Comparison".

This list forms the foundation for the proposed initial skillset as all further steps entail the refinement of the list to be presented in expert interviews for evaluation and refinement. The results of this process can be found in the appendix under “Skill Cross-Comparison”.

4.2.2.5. Step 5: Merge skillsets and remove skills with insufficient value

The result of this step is shown in Table 8. This step entails the first refinement of the identified skillset. All the skills that weigh 0 are removed in this step, as they have not been identified as skills within any of the EA frameworks.

Furthermore, the skills are assigned ranks (1 highest, 4 lowest) according to the number of occurrences across all EA frameworks. This ranking provides an insight into the importance and relevance of the skill according to the weight assigned in the previous step. This ranking will be brought into consideration across the analysis and expert interview section of this research paper.

Table 8: Merged skills

Rank	Skill	Rank	Skill
1	Enterprise IT governance	2	Business modelling
1	Strategic planning	2	Organisational capability development
1	Information governance	2	Organisation design and implementation
1	Information systems coordination	2	Change implementation planning and management
1	Information security	2	Business process testing
1	Information assurance	2	Benefits management
1	Analytics	2	Portfolio management
1	Data visualisation	2	Programme management
1	Information content publishing	2	Project management
1	IT management	3	Emerging technology monitoring
1	Financial management	3	Real-time/embedded systems development
1	Business process improvement	3	Database design
1	Enterprise and business architecture	3	Testing
2	Continuity management	3	Safety engineering
2	Network planning	3	Requirements definition and management
2	Solution architecture	3	Portfolio, programme and project support
2	Data management	4	Service acceptance
2	Methods and tools	4	Configuration management
2	Systems development management	4	Asset management
2	Systems design	4	Change management
2	Software design	4	Release and deployment
2	Programming/software development	4	System software
2	Animation development	4	Capacity management
2	Data modelling and design	4	Security administration
2	Network design	4	Penetration testing

Rank	Skill	Rank	Skill
2	Information content authoring	4	IT infrastructure
2	Demand management	4	Storage management
2	Innovation	4	Network support
2	Research	4	Availability management
2	Knowledge management	4	Service level management
2	Business risk management	4	Systems integration and build
2	Sustainability	4	Porting/software configuration
2	Business analysis	4	Systems installation/decommissioning

4.2.2.6. Step 6: Group skills according to ArchiMate layers

This step entails classifying the identified EA skills into the three ArchiMate layers of *business*, *application and data,* and *technology*. Each identified skill was categorised according to their best logical fit within one of these three layers. No skill was duplicated into multiple layers; thus, each skill was categorized into only one layer.

Additionally, the skill ranking colour-coding was added to the layer distribution, and the average skill ranking was calculated per ArchiMate layer. The following observations can be made from this distribution.

1. The “business layer” contains the most skills, followed by the “application and data layer” and lastly, the “technology layer”.
    a. This shows that the skill distribution was skewed towards “less technical” business skills rather than the more technical skills found in the “technology layer”.
    b. This emphasises the importance of business-related skills within the EA framework that gradually declines in the more technical skills (technology layer).
    c. This is also substantiated by the lack of any “rank 1” skills within the technology layer.
    d. Although the “business layer” contains the most skills, the “application and data layer” has an overall higher-ranking average. This shows that although the skill inclusion of the examined EA frameworks favoured the “business layer”, the “application and data layer’s” skills may be regarded as more important.

The result of categorising the identified EA skills within the ArchiMate layers are shown in Table 9. The rankings are identified according to their colour coding, as found in the legend.

Table 9: Categorised EA skills

Business Layer	Application and Data Layer	Technology Layer	Rank	Colour
Enterprise IT governance	Information systems coordination	Network planning	1	
Strategic planning	Information security	Methods and tools	2	
IT management	Information assurance	Systems design	3	
Financial management	Analytics	Network design	4	
Business process improvement	Data visualisation	Emerging technology monitoring		
Enterprise and business architecture	Information content publishing	Real-time/embedded systems development		
Continuity management	Information governance	Safety engineering		
Solution architecture	Data management	Configuration management		
Systems development management	Software design	IT infrastructure		
Demand management	Programming/software development	Storage management		
Innovation	Animation development	Network support		
Research	Data modelling and design	Service level management		
Knowledge management	Information content authoring	Systems integration and build		
Business risk management	Database design	Porting/software configuration		
Sustainability	Testing	Systems installation/decommissioning		
Business analysis	System software			
Business modelling	Security administration			
Organisational capability development	Penetration testing			
Organisation design and implementation				
Change implementation planning and management				
Business process testing				
Benefits management				
Portfolio management				
Programme management				
Project management				
Requirements definition and management				
Portfolio, programme and project support				
Service acceptance				
Asset management				
Change management				
Release and deployment				
Capacity management				
Availability management				
Average Ranking				
2.76	2.94	1.73		

4.2.2.7. Step 7: Closing remarks on initial skillset that will be used in interviews

This section entailed the creation of an initially proposed skillset. The skills identified were derived from the top four EA frameworks.

Firstly, the core skills for each framework were identified. This identification was made through the analysis of the literature. These core concepts were reinforced through datamining selected documents for each framework to identify themes that could strengthen these linkages.

Secondly, the EA frameworks' identified core concepts were linked to the SFIA skillset to standardize the naming conventions of the skillset so that they could be compared with one

another. This entailed linking core concepts with SFIA categories, standardizing naming conventions, and lastly, the assignment of SFIA skills to each framework.

Thirdly, these skills were then cross-compared to identify relevant skills within the SFIA framework, entailing the elimination of skills that were not found to be noteworthy within the skill identification of the EA frameworks.

Lastly, the list of skills identified (and now merged) skills was categorized within the ArchiMate layers to provide a different viewpoint when analysing the skills and offering a classification model to group skills within.

The following remarks can be made concerning this section.

1. The EA frameworks' core themes could be assigned to the SIFA frameworks, thus being used as a skill generation technique.
    a. It is interesting to note how much overlap there was between skillsets, showing a commonality of focus within these EA frameworks, although each was developed as a standalone framework. (Exception of the Gartner process model)
2. The focus points of each framework could be linked to the themes identified by datamining selected documents of each framework.
3. The core concepts identified showed similar patterns throughout this analysis:
    a. The frameworks emphasised business-related concepts
        i. This was reinforced when the skills were categorised into the ArchiMate layers, showing a skewed skill distribution towards the business layer, i.e., business-related skills.
    b. The frameworks also emphasized IT concepts
        i. This was reinforced by the skill ranking when skills were divided into the ArchiMate layers. This showed that the average skill ranking (relevance) was higher in the application and data layer than in others.
        ii. A noteworthy observation is that although the frameworks emphasised IT concepts, the "technology layer" in the ArchiMate skill classification had a disproportionately lower rank average. This may show that the EA skills might not emphasise technical IT concepts but rather a logical understanding of how they function and contribute to the business vision/objectives.
4. Business-related concepts were by far the most occurring theme within the frameworks.

a. When merging the “application and data layer” and “technology layer’s” average rankings, it provides a 2.39 average, whereas the “business layer” provides a 2.76 ranking. This may show that business-related functions within the EA frameworks are seen as the focal point that is supported by IT functions. “Data and application” IT functions can be seen as the more important category of this broad classification with a 2.94 average ranking and technology as the least important with a 1.73 average ranking.
b. This can be taken a step further and described in the following manner: The EA frameworks focus on supporting business functions within an organisation; these business functions are supported by the application and data functions, and the application and data functions are supported by the technology functions.
    i. This aligns with the ArchiMate models dependency between layers, and it is interesting to note that the ranking and classification of skill supports this model’s dependencies.

This concludes the data generated through the documentation analysis. The initial skillset that was developed in this section was later used in expert interviews to be refined and evaluated. The initial skillset provided was the starting point in the development of an optimal standardized skillset for EA practitioners and shows the first merging of skills within the four analysed EA frameworks.

4.3. Analysis and Findings

4.3.1. Introduction

In-depth expert interviews were conducted with eight Enterprise Architecture (EA) experts. The first round of interviews was conducted based on the initial skillset developed. From this point forward, the EA experts' inputs were used to refine the skillset further.

Two rounds of interviews were held. The study made provision for three rounds of interviews, but after the second round, there was consensus about the skillset and no need for a third round of interviews. There will always be a comment or adjustment requested, but the broad sentiment was that the skillset was well received after the second round of interviews and was thus capped at this round.

The general feedback for the skillset was well received, and the participants were deeply passionate about the feedback they provided. This indicates the importance of such a skillset within EA, as all the participants placed immense value on the skills they perceived as valuable.

The individual skills were adjusted based on a median score from where the enterprise architects placed the skill within the skillset. This median scoring was done through participants identifying how high a skill should be ranked. The median score of this ranking was then used to assign the skill to a different rank, if the score indicated that the skill should be moved. In some cases, the median was not used but the adjustment was based on the importance that the participant placed on the skill. This was done because it became noticeably clear early on that the skills the participant in question held in high regard was naturally centred on the working experience and current working environment of the participant.

If there was no consensus from participants on where a skill should be placed and there where convincing arguments from participants, the adjustment mechanism was adapted to not use median scoring, but rather based on the extend of importance raised by participants. This was done to balance the skillset more evenly by considering the importance placed on a skill (the degree to which the participant argued in favour of the change). It was interesting to note that those skills given a high ranking based on an individual EA's input were agreed upon by other EAs when re-examined. They stated that they could see that the skill could be regarded as important, although it was not currently the same level of importance in their working environment.

This chapter will now focus on each interview round and how the skillset was refined to provide the results of this study.

4.3.2. Round One Interviews

The proposed skillset, as shown in table 8 (without categorisation) and table 9 (with categorisation), that was provided for refinement was received well by the EA experts. The consensus was that most or all (depending on the participant) key skills were present but some adjustments to their importance had to be made, based on their experience.

As the first round of interviews progressed, it was quite interesting to see how much consensus there was around the importance of skills and where they should be placed on the skillset categorisation. Naturally, there were differences between participants' perceptions on the importance of some skills, but it was fascinating to see how much the participants agreed (overlapped) on how a skill should be prioritised in the skillset.

This agreement was without participants being able to review each other's comments and simply agreeing, but rather providing the same indications without any feedback or input from other participants.

While discussing the skillset with the various participants, an interesting pattern emerged that all the participants placed immense importance on the business layer and side of EA. This was apparent because every single participant made this distinction. This shows the importance of business knowledge and understanding as a core function of an enterprise architect and probably to an extent from their perception the number of skills that were placed in the business layer for the skillset.

There were also numerous complaints that business tends to focus too much on IT and its requirements instead of first getting everything correct from a business perspective. A quote from one of the participants grabbed my attention and was quite interesting when taken into perspective with the other EAs' comments.

"Technology has become the tail that is wagging the dog" (Participant 8). The participant further stated that a major problem in EA is that it starts from an IT rather than a business perspective and that this inhibits mobility as most architectural investments are centred solely around IT and not Business.

This statement was echoed through the other interviews where a general disdain towards the importance placed on IT rather than the business was abundantly clear. Many participants

claimed the existence of a tendency to follow a bottom-up approach in organisations rather than a top-down approach where business is the starting point.

All the participants in the study indicated that business should be the driving force and that IT should be the supporting structure. It was interesting to note that the participants, however, upon reflection, stated that this was not generally the case, even though this consensus was formed by all participants. None of the participants undervalued the importance of IT, but rather stated that too much importance was placed on IT in the business.

It was also interesting to note (as brought up by one of the participants) that all the skillsets analysed in the framework were predominantly IT centre frameworks. This might raise the question whether the most used skillsets are skewed towards IT instead of business and if this might be a contributing factor in the understating of business architectures' importance.

With regards to the study, this is an interesting contribution to understand an enterprise architect role that facilitates business growth in conjunction with IT. All the participants indicated that business was the most important, followed closely by IT, but not the other way around. The first skillset iteration, with the ArchiMate layer classification and change list, can be found in the Appendices under "Skillset 1st iteration".

4.3.2.1. Observations from Changes

As stated previously, it was interesting to note that although the interviews were held in isolation from other participants, there was consensus around where skills should be placed.

From these changes, that can be found in the appendix under "Appendix E: Change list", the most interesting was organisational capability development. All inputs received on this skill indicated that it should be moved to a rank 1 skill, highlighting its importance. Other skills worth mentioning that had strong consensus on where they could be moved are highlighted in the rest of this section.

Business risk management, business modelling, change implementation and management were moved to rank 1. There was a high level of consensus that these skills should be seen as core EA skills, and their importance should be highlighted to conduct effective work as an enterprise architect.

Service level management that moved to the business layer and a rank 2 classification also received a high level of consensus to where it should move, and it is interesting to note that many positive inputs were received, indicating that the skill should be seen as more important, but not as a core (rank 1) skill of EA. This can be seen as a strong supporting skill for EA practitioners as perceived by the number of inputs received regarding its importance.

On the other hand, database design and animation development were seen as non-essential skills. This issue was raised to such an extent that database design was removed from the skillset.

Additional skills that were not provided on the initial skillset were also identified by the participants and can be seen on the bottom of the table provided in the appendix under “Appendix E: Change list”. They are as follows:

1 Business Governance: This skill was added after discussing the importance of IT governance and the omission on the business side of this from the skillset.
2 Emerging business monitoring: This skill was added based on emerging technology monitoring provided in the skillset. The participant highlighted that the emerging business patterns are just as important to monitor and are often overlooked. An example provided was regarding the COVID-19 pandemic. The participant stated that because emerging business monitoring was not implemented, some businesses struggled to initially cope with the new regulations brought forth during the pandemic. The participant felt that some of these challenges could have been mitigated with the appropriate contingency plans. Thus, the participant highlighted the importance of enterprise architecture work in business processes and changes that could be necessitated because of internal or external changes and how important it is to consider this to the same extent as emerging technology monitoring.
   Additionally, it is interesting to note that this is also present in the Gartner process model where the external environment influences the architectural work.
3 Strategic Marketing: This skill was added based on a participant indicating its importance in their current working environment. The participant stated that there is a gap between business understanding and EA and that strategic marketing closes this gap as it helps show stakeholders the value that will be brought to market.
4 Process engineering: This skill was added to the skillset based on a participant indicating the importance of this skill and that this can also be seen as an overarching skill for business process testing, business analysis and business modelling.
5 Systems Thinking: This was added based on the input from a participant that indicated this skill assists with understanding how changes influence systems and the business and how these two areas fit together.
   In essence, this can be seen as a core function of an enterprise architect to understand how the business systems fit into each other and how they influence each other, as this plays a major part in the implementation of architecture deliverables and how they interact with the environment.

6 Information Modelling: This skill was added based on input from a participant that indicated that this skill is needed to provide information artefacts for visualizations as an enterprise architect.
7 Component-Based Design: This skill was added based on input from a participant that indicated this skill is needed to understand the creation of components within an organisation and building products from these components. The participant stated that the enterprise architect might not be interested in the design of these components but rather how the components can be implemented in the architectural design.
8 Technology Modelling: This skill was added based on a participant indicating its importance and that there was no current provision made for the skill within the current skillset.
9 Lifecycle Management: This skill was added based on a participant indicating the importance of lifecycle management and the need for an enterprise architect to understand its concepts and implementation. The skill can be seen as an overarching skill/classification of system installation and decommissioning.

4.3.3. Round Two Interviews

On presenting the second iteration of the Skillset to participants, there was an overwhelming consensus that the skillset was in good standing. Although a few changes occurred to reach the final skillset, the overall feedback from participants was that they found the skillset in good order. The skillset provided can be found in the appendix under “Appendix C: Skillset 1st Iteration All skills” and “Appendix D: ArchiMate Layer Classification”.

This consensus drives the decision to cap the interviews with this round. There will always be participants that want to adjust and make changes, but after conducting the second round of interviews and gathering all the inputs, the decision was made to finalise the skillset based on these final comments.

The inputs received from the second round were measured against responses from the first round of interviews to mitigate any risk of skewing the skillset when the definitive version was developed.

An interesting note was that the participants welcomed the new skills added to the skillset. They indicated they could see why the skills were brought in and seen as important, although it may not currently affect them. The outlier to this was strategic marketing. Many participants did not see the value within this skill regarding EA and indicated it should be ranked lower.

One participant indicated that it might be a new skill emerging in the domain as EA is evolving and that there is merit to keeping it on the skillset although at a lower importance level.

The consensus among the EA experts was welcoming. It showed that the evaluation and refinement of the skillset held up to their expectations and the interview process did not skew the relevancy of skills within the skillset. This could be observed, as the number of changes applied in this interview round was much less than the previous round, as can be seen in the appendix under “Appendix F: Skillset 2nd Iteration Change List”. This highlights that the participants expectations were aligned with the outcome of the altered skillset presented to them.

It is also interesting to note the consensus between the skill classifications of the participants as the interviews were held separately, and the skillset still conformed with their requirements. There will always be suggestions for changes, but the overall feedback was that the skillset aligned with their needs to be an effective EA practitioner.

Another interesting observation is that the enterprise architects were pleased with the skills contained in the business layer and agreed with its perceived importance compared to the others, i.e., the number of rank 1 skills included in this layer.

As stated previously, all the participants placed immense importance on the business side of EA, and it is expected that their skill classification would reflect this. Nonetheless, it is still an interesting observation that the participants continued emphasising the importance of the business layer skills in the second round of the interview process. This underlines the importance of the business side of EA and can be seen as a critical skill acquisition category to prioritise as an EA practitioner.

4.3.3.1. Observations from Changes

As previously stated, there was consensus with the second round of interviews that the skillset was sufficient to identify general EA skills required for a practitioner to carry out their duties effectively and efficiently.

This statement is also reflected in the change list, where significantly fewer changes were made to the skillset provided as compared to the first round of changes. This can be seen when comparing the first change list with the second change list found in the appendix respectively under “Appendix E: Change list” and “Appendix F: Skillset 2nd Iteration Change List”. The feedback from the second round of interviews was considered with the first round to ensure that changes made to the final iteration would not skew the participants' inputs. Thus, all remarks were considered as a whole and not isolated to the current interview round.

Therefore, the decision was to stop the interview process after the second round of interviews as consensus about the skills was reached at that stage.

An interesting discussion with one of the participants raised the need for soft skills. Interestingly, this was only mentioned once throughout the interview process (at such a late stage). Participants were generally only concerned with the skills provided (that did not include any soft skills as a limitation to the study).

The participant raised the importance of soft skills for enterprise architects and said this could play a key role in their effectiveness and influence their ability to be employed. As stated in the limitations section of this study, soft skills were not included in the skillset. However, it would be interesting to see what soft skills benefit the EA domain and how they influence a practitioner's ability to practice the discipline.

The skills that did not make an impression on the participants were animation development and strategic marketing. Animation development was discussed in the light of "creating simulations" rather than graphical animation implementation. The consensus was that this skill should not be regarded as a general skill for EA practitioners and was thus removed.

Strategic marketing was held in high regard by one of the participants, but the other participants did not see the value of this skill. It was thus moved to a rank four importance level. The skill was not removed because discussions with some participants leaned towards a potential benefit in keeping the skill at a lower ranking. The argument was that this might not be a currently accepted skill within EA but might provide future value as the discipline evolves. The skill was kept based on this reasoning as it may provide benefits to practitioners as a supporting skill, but not as one of the general core skills identified in the Skillset.

The changes of "Release and Deployment" and "Capacity Management" moving to the Technology layer was a fascinating argument, as the participant stated that they require the "Network Planning" skill within this layer to be implemented. The participant further argued that they fit into a technology package consisting of "Network Planning", "Configuration management", "Storage Management", "Release and Deployment", and "Capacity management." It is interesting to note that these groupings appeared in the skillset. Throughout the interview process, numerous remarks of skills fitting together were made, although this argument was the most compelling and justified this grouping of skills.

Participants often viewed skills in packages, and it was interesting to see that although the participants identified some skill sub-groupings, it did not mean that all skills within the grouping were regarded as equally important.

This raises the question of core and supporting skills within the EA skillset. It seems that practitioners overwhelmingly regarded certain skills as particularly important and would make immense arguments about their importance where the need for other skills was not argued with a similar passion. This highlights the probability of the core skills within EA requiring supporting skills that assist in effectively implementing the core skill in practice.

The importance of these core skills' importance was almost identically promoted by the participants. An example from the first round of interviews highlights this, where five out of the eight participants indicated that "Organisational Capability Development" should be a rank 1 (core skill), even though these participants differed in their perceived importance of other skills. It would be interesting to examine the skillset further in a future study to identify these core and supporting skills within packages, as the current skillset ranks all skills together. This categorisation may further the understanding of core skills in the discipline and which skills support their effective and efficient implementation.

The proposed skillset does provide a skill ranking that can be classified from core to supporting skills, but they are not broken down into "packages". These packages where EA experts indicated that skills fit together would be interesting to explore. This exploration may provide a more condensed view of skill requirements for EA practitioners as core skill packages and their supporting sub-skills. This approach may also provide insight into the core implementation areas of EA in practice as an extension of these skill packages.

Most of the changes made in this iteration were minimal based on the general acceptance of where the skills should be ranked based on the complete interview process. The second skillset iteration change list can be found in the appendix under "Skillset 2nd iteration".

4.4. Conclusion

Interviews with eight EA experts were held over two rounds. The feedback from participants was taken into consideration across all interview rounds and participant inputs. Median scoring of skill ranking and classification were the main tools used to adjust the skillset, but qualitative inputs based on participant feedback was also considered when adjusting the skillset.

The process resulted in a skillset that was generally accepted by the participants as a skillset for EA practitioners and not isolated within specific implementations and frameworks. Table 10 shows the final version of the skillset after the second round of iterations have been completed. This is the main contribution of the study providing an optimal standardized classification of enterprise architecture skills.

Table 10: Ranking of skills

Rank	Skill	Rank	Skill
1	Business Strategic Planning	2	Analytics
1	IT Strategic Planning	2	Systems integration and build
1	Requirements definition and management	2	Configuration management
1	Information security	2	Systems installation/decommissioning
1	Enterprise IT governance	2	IT infrastructure
1	Information assurance	3	Information systems coordination
1	Innovation	3	Benefits management
1	Research	3	Business process improvement
1	Business risk management	3	Project management
1	Business analysis	3	Security administration
1	Business modelling	3	Business process testing
1	Organisational capability development	3	Sustainability
1	Systems Thinking	3	Data visualisation
1	Business Governance	3	Change management
1	Change implementation planning and management	3	Information content publishing
1	Emerging business monitoring	3	Systems development management
1	Portfolio management	3	Network planning
1	Organisation design and implementation	3	Release and deployment
1	Information Modelling	3	Capacity management
1	Enterprise and business architecture	4	Strategic Marketing
1	Data management	4	Programme management
1	Systems design	4	Portfolio, programme and project support
1	Process Engineering	4	Safety engineering
1	Data modelling and design	4	Porting/software configuration
1	Solution architecture	4	System software
1	Emerging technology monitoring	4	Asset management
1	Component based design	4	Systems Testing
1	Technology Modelling	4	Programming/software development
1	Lifecycle Management	4	Software design
2	Continuity management	4	Information content authoring
2	Demand management	4	Methods and tools
2	Product and Service acceptance	4	Network design
2	Financial management	4	Real-time/embedded systems development
2	Information governance	4	Storage management
2	IT management	4	Network support
2	Service level management	4	Penetration testing
2	Knowledge management		
2	Availability management		

The process also resulted in creating a generally accepted skillset by participants categorised into the three ArchiMate layers as shown in Table 11 below, providing an additional viewpoint of EA skills packaged in the business, data and application, and technology layers. The table provides two contributions made through the study, firstly, a generic classification of enterprise architecture skills categorized according to the three ArchiMate layers of business, application and data, and technology and secondly, and Inter-rankings of skills according to ArchiMate Layers

Table 11: Skillset categorised into the three ArchiMate layers

Business Layer	Application and Data Layer	Technology Layer
Business Strategic Planning	Data management	Emerging technology monitoring
IT Strategic Planning	Systems design	Component Based Design
Requirements definition and management	Process Engineering	Technology Modelling
Information security	Data modelling and design	Lifecycle Management
Enterprise IT governance	Solution architecture	Configuration management
Information assurance	Availability management	Systems installation/decommissioning
Innovation	Analytics	IT infrastructure
Research	Systems integration and build	Network planning
Business risk management	Data visualisation	Release and deployment
Business analysis	Change management	Capacity management
Business modelling	Information content publishing	Methods and tools
Organisational capability development	Systems development management	Network design
Systems Thinking	Safety engineering	Real-time/embedded systems development
Business Governance	Porting/software configuration	Storage management
Change implementation planning and management	System software	Network support
Emerging business monitoring	Asset management	Penetration testing
Portfolio management	Systems Testing	
Organisation design and implementation	Programming/software development	
Information Modelling	Software design	
Enterprise and business architecture	Information content authoring	
Continuity management		
Demand management		
Product and Service acceptance		
Financial management		
Information governance		
IT management		
Service level management		
Knowledge management		
Information systems coordination		
Benefits management		
Business process improvement		
Project management		
Security administration		
Business process testing		
Sustainability		
Strategic Marketing		
Programme management		
Portfolio, programme and project support		

Across the two rounds of interviews, the similarity of responses to specific skills was interesting to witness when compared to the general un-alignment of opinions on other skills. Even though there were significant differences in views and perceptions of importance when looking at the first iteration of the skillset, it is interesting to note the consensus when the skillset was adjusted.

A concerning issue with the study was that the participants' views might be completely different, and that the skillset might not conform to a generally accepted one between participants. If this were the case, it would also be interesting to see the complete difference in views; however, the skillset did conform to one that all participants agreed to, to a large extend. This finding shows that although the perceived importance of a skill is strongly aligned to a practitioner's current working environment, core skills are still relevant within the EA domain that might not have a direct bearing on the practitioners' current work.

The working environment of an enterprise architect seems to play a significant role in the perceived importance of certain skills, and this will always cause an adjustment to be made. This finding shows that the perception of the importance of a skill can be skewed depending on the current working environment of an EA practitioner.

The goal of the skillset is to be a generally acceptable representation of skills within the EA discipline. The participants of the study were diverse enough to bring different viewpoints to the skillset. Although each skill might not be perceived as equally important by all enterprise architects that reflected on their current working environment, it may be seen as equally important when viewing the discipline as a whole and not in isolation in these specific implementations.

It was welcoming to see that participants valued the importance placed on skills by other participants and appreciated the value that the skill might hold in a different working environment. This shows the vastness of the discipline where practitioners of EA face different challenges although, in essence, fulfilling the same duties.

The interview process highlighted the similarities of EA when looking at the skills that are required to implement the discipline while also in stark comparison highlighting the differences between importance depending on the practitioner's current environment.

This may always be the case as one working environment may place different importance on specific duties compared to another. However, the participants were still able to agree and understand each other's working environments as consensus was achieved when looking at the skills from the viewpoint of an enterprise architect in general and not just within a specific environment.

CHAPTER 5: CONCLUSION

5.1. Introduction

This section entails a final discussion of observations made during the study and concluding remarks. The section also summarises the findings made throughout the study, the contributions made, and proposals for future research that can be conducted to understand the skillset of EA and its application better.

This section also aims to provide a final discussion about the skillset that emerged through the research process and refinement by the EA experts. Lastly, this section contains a summary of how the research questions were answered and the research objectives reached.

The study entailed an analysis of the top four EA frameworks identified as the Zachman Framework for Enterprise Architecture, the Open Group Architectural Framework, the Federal Enterprise Architecture Framework and the Gartner Enterprise Architecture Process Model.

After the literature about the frameworks was reviewed to identify specific themes within each framework, the frameworks were analysed to identify the core skills of EA. The naming conventions of these skills were then standardized to provide a consistent naming convention and definition for the skills through the SFIA framework. After that, the skills were ranked according to their relevance identified in the data mining process as well as importance identified through the analysis of each framework.

The skillset was then further broken down into the three ArchiMate layers of business, application and data, and technology to provide a different viewpoint to examine the skillset. It is worth mentioning that the skillset proposed in this study is based on the ranking list without the layer classification, as the aim of the study was to establish an optimal standardised skillset for EA practitioners, but nonetheless, the layer classification provides valuable insights that will be discussed in this chapter.

After providing an initial skillset, expert interviews could take place to evaluate and refine the skillset. The result of these interviews was the final proposed skillset, and the main contribution of this study is to understand the skill requirements of EA as a discipline and not as isolated implementations.

5.2. Closing Remarks

The study focused on addressing the problem of a lack of standardization for the EA discipline (Schöenherr, 2008) regarding a generally acceptable skillset as discussed in Chapter 1. The

potential benefits (Hoogervorst, 2004) of a generally acceptable skillset EA were indicated alongside the negative consequences of employing EAs that do not have the necessary skills at their disposal (Kumari, 2012).

The analysis of available literature on the top four EAFs conducted in Chapter 2, as identified by Cameron and McMillan (2010), provided a starting point to identify core themes of the Zachman, FEAF, TOGAF and Gartner approaches to EA. This analysis and identification of core themes allowed SFIA to be used as a standardization framework to which core themes identified in Chapter 2 could be linked.

The ArchiMate framework, as discussed in Chapter 2, allowed an additional classification of EA skills into the three layers of business, applications and data, and technology. The examination of the chosen EAFs applicability into this categorization was also established and was well received by EA experts in the interview process as an analysis approach, providing additional insights and subcategorisation of the identified EA skillset.

The analysis of the top four EAFs alongside the data generation method explained in Chapter 3, resulted in the creation of an initial skillset that was not focused on a specific EA framework, but instead on a combination of the four frameworks selected that could be used in expert interviews to evaluate and refine into a final proposed skillset. The interview process yielded multiple insights and resulted in the creation of a generic EA skills classification.

The most apparent observation made in this study is that all EA experts placed immense importance on the business layer skills within the classification. Furthermore, when asked what layer they viewed as the most important, all indicated that the business layer is the most important without question. Most feedback indicated that without the proper foundation in the business layer, any architectural efforts would most certainly fail, and that business provides the driving force to implement the other two layers. This is the first finding of the study, where it is identified that there is immense importance placed on business-relates skills regarding the skill requirements for EA practitioners.

When viewing the initial skillset created before evaluations (shown in table 8 and table 9), it is interesting to note that the business layer could also be considered the most important when looking at the skill distribution. This skillset was created from the core themes identified in Chapter 2 through the data generation process. It is interesting that the literature also seems to reflect this importance on the business layer due to the data generation process executed in Chapter 4.

Multiple participants also declared that organisations often put IT efforts and architecture before business efforts and architecture and that there is a mismatch of desired outcomes. The bottom-up approach was said to be favoured by most organisations the participants found themselves in, but the consensus was that a top-down approach would provide move benefits to the organisation as it should ensure that the result of the architectural efforts is in line with the organisation's vision and mission.

It is interesting to note that the result of the proposed skillset also reflects this viewpoint, where the amount of rank 1 skills in the business layer far outweighs the rank 1 skills in the other layers. The extent of this is so large that the amount of rank 1 skills within the business layer is more than double the rank 1 skill from both the application and data layer and technology layer combined.

The same observation as explained above can be made about rank 2 skills within the skillset. Only at rank 3 skills does the number of skills start to balance, and at rank 4, the business layer is outweighed by the other two layers.

Another observation that can be made is that the application and technology layers seem to be mostly supporting skills and that the requirements for EA practitioners (in line with skill requirements) is predominantly focused on business-oriented skills. This effect can also be seen from the average skill ranking for each layer, where the business layer ranks at an average of 1.82, the application and data layer at 2.75 and the technology layer at 2.69.

The number of skills within the business layer is also vastly greater than the number identified in the other two layers. It is interesting to note that the initial skillset before refinement was also skewed towards the business layer and that the result of the research process reflected the same outcome, although the contents of the layers changed.

It would be interesting to investigate why all participants in the study view the business layer as the most important and that the majority of participants complained that organisations focus on IT efforts when the driving force should come from business. If most participants are aligned with a top-down approach, why is this approach not employed in most organisations?

Another quite interesting observation is how disperse yet consistent participants were in ranking skills according to their perceived importance. The first round of interviews quickly identified that each participant viewed specific skills as especially important, but they might not be perceived at the same level of importance by other participants. This is the second finding of the study where it is identified that the perception of the importance of a skill can be skewed depending on the current working environment of an EA practitioner. This may be due

to the participants' current working environment in which they place special importance on specific skills. However, there was still an overarching agreement towards the ranking of skills.

When the first iteration of the skillset, shown in the appendix under "Appendix C: Skillset 1st Iteration", was refined through the feedback obtained from the various experts, patterns emerged that aligned the skill ranking for the second iteration. These patterns emerged without participants working among each other and discussing their inputs. In other words, all participants were interviewed in isolation, but the skills rankings were still aligned when all the interviews were examined. This means that although one participant could place immense importance on a skill, for example, rank 1, the other participants also identified that the skill was important but indicated a mixture that aligned to a high ranking of one or two, for example. It is interesting to note that this happened for the most part within the refinement process and that there were almost no split views regarding skill importance in terms of alignment from core to supporting skills.

This shows that there are common themes regarding skills within EA that are viewed as valuable and, in the same sense, other skills that hold less value and can be seen as supporting skills. This is the third finding of the study, where it is shown that although the perceived importance of skill is strongly aligned to a practitioner's current working environment, core skills are still relevant within the EA domain that might not have a direct bearing on the practitioners' current work. This can also be seen when comparing the change lists between the first and second iteration of the skillsets, where the number of changes were fewer, showing that the skillset was conforming to the participants expectations. This comparison can be seen when viewing the two iterations found in the appendix under "Appendix E: Change list" and "Appendix F: Skillset 2nd Iteration Change List" respectively.

To pursue the previous discussion further, it was also interesting to note that the EA experts could relate to the importance of a skill regarding its placement in the second round. The second iteration reflected the inputs from all participants, and the skillset naturally reflected inputs that participants did not specifically mention. However, the EA experts could relate to the importance of the skill ranking even though it may not be as important in their current working environment.

Again, the participants' responses showed a pattern of what skills they viewed as important and that core skills could be identified. This showed that an overarching skillset for EA can be identified, and the skills can be seen as important in the EA domain as core skills for the discipline and that participants were able to make this distinction.

The study aimed to identify an optimal standardised skillset for EA practitioners that is not isolated in specific implementations, and participants supported this argument by being able to perceive and acknowledge the importance of general EA skills that may fall outside their domain and showed that such a core skillset could be provided for the discipline as these core themes in skill classification were identified.

This may be why the current EA frameworks are isolated in their skill requirements as reflected by the participants and the importance they placed on a skill within their current working environment. It makes sense that these frameworks originated to address the challenges of a specific working environment (in a general sense), and the frameworks' skewness towards IT centred skills might be due to the tendency of organisations to follow a bottom-up approach as identified by the participants of this study.

It was encouraging that the participants were not narrowly focused on only the skill requirements they currently utilised but could relate to the importance of other practitioners' skill rankings. This strengthens the argument that a generally acceptable skillset for EA at its core can be identified where practitioners can then specialise in specific implementations. This is the fourth finding in this study, where it is identified that a classification of generic enterprise architecture skills has been identified by investigating the top four enterprise architecture frameworks and then refined through expert interviews.

The aim of this study is to identify an optimal standardised skillset for EA practitioners. This aim was achieved through the provision of this Skillset as the main contribution for this study that highlights common themes within EA and provides an optimised standardised skillset for EA practitioners that has been evaluated and refined through the expert interview process. This contribution can be seen in Chapter 4 on table 10. This skillset provides current and future practitioners of EA with a guide in the general skill requirements for EA as identified through the analysis of the top four EA frameworks and methodologies that were refined and evaluated through expert interviews.

This skillset provides valuable insights into the understanding of EA in practice as an extension of general skill requirements. This is the fifth finding in this study that identified a classification of generic enterprise architecture skills that has been ranked according to feedback from expert interviews and classified in the three-layer ArchiMate classification, shown in table 11. The study's aim was to identify an optimal standardised skillset for EA practitioners. The study concluded that this skillset could be generated through the analysis process conducted in Chapter 4. The proposed skillset and main contribution of the study as shown in table 10 is the provision of this skillset that has been evaluated and refined through expert interviews.

Regarding the research questions identified in Chapter 1, they were answered as follows:

1. **What are the required skills to practice the top four Enterprise Architecture frameworks or approaches?**

This question was answered in Chapter 4. The top four EA skillsets were analysed through the data generation plan that used the core themes identified through the analysis conducted in Chapter 2 to identify an initial skillset to be reviewed by EA experts. The result and main contribution of this thesis is the final proposed skillset. This can be seen in Chapter 4 on table 10.

2. **How can a generic skillset for Enterprise Architecture practitioners be classified?**

This question was answered in Chapter 4, where the data generation plan was used to categorise the skillset into the ArchiMate layers of business, application and data, and technology. This classification and the applicability thereof regarding the selected EAFs were identified in Chapter 2 where the EAFs' core themes were linked to the ArchiMate layers. Lastly, the skillsets were standardized in Chapter 4 using the SFIA framework, initially identified in Chapter 2 to standardize the skills across the four EAFs. The result of this classification can be seen in Chapter 4, table 8 and table 9, providing a starting point and generic classification that could be used for refinement in the subsequent interview process.

3. **What are the focus points (regarding skills) for enterprise architects?**

This question was answered in Chapter 4 through the finalised skillset, which was generated by analysing the top four EA frameworks and refined through evaluation and feedback provided by the EA experts. The expert interview process identified that immense importance was placed on the business layer and business orientated skills within the EA domain.

Furthermore, the skill rankings of the finalised skillset provide a list of core skills (rank 1 skills), that indicate the focus points (regarding skills) for EA practitioners. This list of core skills and the finalised skillset can be seen in Chapter 4 table 10.

4. **What is the inter ranking of skills, regarding their importance, to practice Enterprise Architecture in general?**

This question was answered in Chapter 4 through the finalized Skillset that shows skills ranked from 1 (core skills) to 4 (supporting skills).

The ArchiMate classification was introduced in Chapter 2 to link core themes identified in the four EAFs and used to categorise the identified skills in Chapter 4. The ArchiMate classification

provides an additional classification and inter ranking of skills. This classification allows the inter ranking of skills within the business, application and data, and technology layers. This provides an inter ranking of business, application and data, and technology orientated skills and can be seen as ranging from less-to-more technical skills. This inter ranking of skills can be seen in chapter 4 on table 11.

Regarding the research objectives in Chapter 1, they were achieved as follows:

1. To identify the main skills an enterprise architect requires in the discipline of Enterprise Architecture concerning the top four EA frameworks

The proposed skillset was created by analysing the top four EAFs, where core concepts of the EAFs were identified and processed into an initial skillset used for refinement. The main skills required for EA practitioners has been identified in Chapter 4 table 10 where a ranking of skills is provided with the identified skills, showing core (rank 1) skills to supporting (rank 4) skills.

2. To identify generic Enterprise Architecture skills for practitioners that can be applied as a general foundation to the entire discipline of EA

The generic EA practitioner skill classification is provided in Chapter 4 table 10. The table identifies a generic skills classification for EA that is not centred on specific implementations but comprises of the inputs from various EA experts that practice the discipline in multiple heterogenous environments with different core functions.

3. To identify the inter-skill importance of generic Enterprise Architecture practitioner skills.

The inter-skill importance of generic EA practitioner skills has been identified in Chapter 4 table 11. The table provides a sub-categorisation of skill importance broken into four ranks, where rank 1 skills are perceived as the most important and rank 4 skills as least important. This categorisation provides an inter-skill ranking of the skillset that has been established through the analysis of the top four EAFs and revised through expert interviews.

5.3. Summary of Findings

1. **There is immense importance placed on business-related skills regarding the skill requirements for EA.**

As discussed, all participants viewed the business layer as the most important skill classification for EA related skills. Furthermore, they placed immense emphasis on getting the business side correct before moving over to the domains of technology, application and data,

as a misalignment between business and these domains entails a high likelihood of a failed implementation.

2. **The perception of the importance of a skill can be skewed depending on the current working environment of an enterprise architect practitioner.**

As discussed, the perceived importance of skill was highly centred around the current working environment and requirements that a practitioner needed. This emphasis makes sense as these are the skills that the participant currently employed to conduct their duties as enterprise architects.

3. **Although the perceived importance of skill is strongly aligned to a practitioner's current working environment, core skills are still relevant within the EA domain that might not have a direct bearing on the practitioners' current work.**

As discussed, the participants could perceive the importance of skills for EA in general rather than the isolated implementation in their current working environment. This shows that there are core themes regarding a required skillset for the discipline as participants were able to rationalise the importance placed on a specific skill by other practitioners in different working environments.

4. **A classification of generic enterprise architecture skills has been identified by investigating the top four enterprise architecture frameworks and then refined through expert interviews.**

The study's core finding is the skills classification presented, as the goal was to identify a generic set of skills within EA that can be applied to the discipline as a whole and not only to specific implementations.

The skillset provides a list of generic EA skills ranked into four categories, where the first rank can be seen as core skills and the fourth rank as underlying or supporting skills. This list provides a generic mix of skills that can be applied to the domain of EA.

These skills were evaluated and ranked according to inputs provided by EA experts that practice the discipline in multiple heterogenous environments with different core functions. This evaluation and refinement provide a skillset for EA that is not centred on specific implementations but comprises the inputs from these various EA experts for the discipline.

5. **A classification of generic enterprise architecture skills has been ranked according to feedback from expert interviews and classified in the three-layer ArchiMate classification.**

The skill classification within the ArchiMate layers provides a viewpoint towards generic EA skills that could not be obtained through only a listing of skills.

The EA experts provided feedback on this classification as skills were allocated to the layer identified in these interviews. This feedback provides a view of the proposed skillset divided into business, data and application, and technology layers.

The layers can also be viewed as a scale from business-related skills to more technical skills and highlight the importance that the EA experts placed on the business-related skills that an EA should have at their disposal. This view also provides an inter-ranking of skills within the layered classification, providing another dimension to analyse these skills. This view allows us to identify the most important skills for EA as identified by participants and the most important skills within each layer classification.

5.4. Summary of Contributions

Below is a list with a brief description describing the contributions made throughout this study.

1. **A generic classification of enterprise architecture skills.**

The main contribution of this study is the provision of a generic skills classification for EA that can be applied to the discipline as a whole and is not limited to specific implementations. This contribution can be seen in Chapter 4 table 10. The skill classification provides a ranking of skills based on the importance identified through the analysis of the top four EA frameworks as identified in this study. The skill classification was then evaluated and refined through expert interviews from various heterogeneous working environments to provide a well-rounded skillset for the discipline in general.

2. **A generic classification of enterprise architecture skills categorised according to the three ArchiMate layers of business, application and data, and technology.**

The second contribution of this study is the skills classification that has been categorised according to the three ArchiMate layers. This contribution can be seen in Chapter 4 table 11. This provides an additional viewpoint to examine the proposed skillset. The skills were evaluated and refined through expert interviews, where participants could adjust the skill classification. This classification can be seen as an alternative viewpoint where skills can range from business orientated to more technical skills (business layer to technology layer) and provides the skill breakdown requirements for each layer.

3. **Inter-rankings of skills according to ArchiMate Layers**

The ArchiMate layered classification of skills provides an inter ranking of skills based on each layer that would not be possible with a standard list. This contribution can be seen in Chapter 4 table 11. This approach provides a classification of core (rank 1) skills to supporting (rank 4) skills within each ArchiMate layer. The inter ranking of skills highlights the importance that enterprise architects place on each layer. This ranking helps identify the importance enterprise architect experts placed on the business layer, highlighting the importance of business-oriented skills for the EA domain.

5.5. Future Research

The list below indicates future research that can be conducted based on questions that arose in this study.

1. **Identify the required soft skills that enterprise architecture practitioners need at their disposal to practice the discipline effectively and efficiently.**

One limitation of this study is the exclusion of soft skills to accompany the skillset provided. In the interview process, a participant raised the importance of soft skills to conduct work effectively and that they play a key role in the job selection process.

It would be interesting to identify what soft skills are required by enterprise architects and what the consensus within the domain is regarding the importance of soft skills.

2. **Identify how to measure the productivity of an Enterprise Architect.**

This future research topic also stems from conversations held with participants. This study focused on the skill requirements for an enterprise architect in general, but the study did not look at how these skills are implemented in practice to ensure optimal efficiency and quality.

It would be interesting to identify how an enterprise architect's productivity can be measured to ensure that the quality of work being done is acceptable and determine what factors affect their performance. The research can provide insights on the success factors for an enterprise architect and the key performance indicators of an enterprise architect to function effectively.

3. **Identify the core business functions that an enterprise architect conducts in general.**

Discussion with participants indicated that enterprise architects often perform tasks that might not be strictly in line with the discipline. Discussions indicated that the size of organisations

might play a role in the working requirements for an enterprise architect and can influence what their daily duties comprise.

It would be interesting to investigate the current working environments of enterprise architects in varying organisations sizes to identify the core work responsibilities of enterprise architects in general and if the organisation composition plays a role in the work that enterprise architects carry out.

4. Identify sub-skill groupings within enterprise architecture.

Discussions with participants indicated that skills were often viewed in packages. It would be interesting to identify core skill packages for EA, in general, to determine the composition of core skills and supporting skills within each of these skill packages.

This may provide a more condensed view of skill requirements for EA as core skill packages and their supporting sub-skills. This may also provide insight into the core implementation areas of EA in practice as an extension of these skill packages.

BIBLIOGRAPHY

Abdallah, S., & Galal-Edeen, G. 2006. Towards a framework for enterprise architecture frameworks comparison and selection. *The Fourth International Conference on Informatics and Systems*, 1–10. Available at http://ggatz.com/images/ISA_frameworks.pdf. [Accessed 15 November 2021]

Bittler, R.S., & Kreizman, G. 2005. Gartner Enterprise architecture Process. *Evolution 21.*

Bondar, S., Hsu, J. C., Pfouga, A., & Stjepandic, J. 2017. Zachman framework in the agile digital transformation. *Advances in Transdisciplinary Engineering*, 5, pp. 67–74. https://doi.org/10.3233/978-1-61499-779-5-67

Braun, V. & Clarke, V. 2012. Thematic analysis. APA handbook of research methods in psychology. *Research Designs, Vol. 2,* pp. 57-71. Washington, DC: American Psychological Association

Buckl, S., Ernst, A. M., Matthes, F., Ramacher, R., & Schweda, C. M. 2009. Using Enterprise Architecture Management Patterns to complement TOGAF. In *2009 IEEE International Enterprise Distributed Object Computing Conference* (pp. 34-41). IEEE.

Cameron, B. H., & Mcmillan, E. 2010. Analyzing the Current Trends in Enterprise architecture Frameworks. *Journal of Enterprise Architecture*, 9(1), *pp.60-71.*

Cardwell, G. 2007. The influence of Enterprise Architecture and process hierarchies on company success. *Total Quality Management and Business Excellence*, 19(1–2), pp. 47–55. https://doi.org/10.1080/14783360701601959

Checkland, P. 2000, Soft systems methodology in action: includes a thirty-year retrospective, *Systems Research and Behavioral Science*,.17, pp. 11–58.

Dang, D. & Pekkola, S. 2016 Root Causes of Enterprise architecture Problems in the Public Sector. *PACIS Proceedings,2016,* pp. 177–198

De Vries, M. 2010. A framework for understanding and comparing Enterprise Architecture models*. Management Dynamics Volume*, 19(2), pp. 17–29.

DePalo, P., & Song, Y. T. 2012. Healthcare interoperability through Enterprise Architecture. In *Proceedings of the 6th International Conference on Ubiquitous Information Management and Communication* (pp. 1-6).

Dispersion and Interconnection: Approaches to Distributed Systems Architecture. June 1986, *PRISM Final Report*. [Online]. Available at: https: / / cdn.ymaws.com / www.globalaea.org / resource / collection / EAAC3D6C-D447-451C-AC5F-6E1DC7788D42 / PRISM_Report.pdf [Accessed 4 June 2019]

Drobik, A. 2002. Enterprise architecture: Far Too Important to Be Left to the IT Team, *Gartner Report*, July 2002, pp. 1–5.

Federal Enterprise architecture Framework Version 2 2013. Federal government of the United States. [Online]. Available at https: / / obamawhitehouse.archives.gov / sites / default / files / omb / assets / egov_docs / fea_v2.pdf [Accessed 3 June 2019]

Gerber, A., Kotzé, P., & Van Der Merwe, A. 2010. Towards the formalisation of TOGAF content metamodel using ontologies., pp. 54–64. https://doi.org/10.5220/0002903200540064

Goethals, F. 2005. An Overview of Enterprise Architecture Deliverables. *SSRN Electronic Journal,* pp. 1–21.

Goles, T. & Hirschheim, R. 2000. The paradigm is dead, the paradigm is dead...long live the paradigm: the legacy of Burrell and Morgan. *Omega*, 28(3), pp.249-268.

Hevner, A. R. 2004. Design Science in Information Systems Research. *MIS Quaterly*, 28(1), pp.. 75–105.

Hoogervorst, J. 2004. Enterprise architecture: Enabling Integration, Agility, and Change. *International Journal of Cooperative Information Systems*,13,(3), pp. 213–233.

Iyer, B. & Gottlieb, R. 2004. The Four-Domain Architecture: An approach to support enterprise architecture design. *IBM Systems Journal*, 43(3), pp. 587–597.

Johnson, R. B., & Onwuegbuzie, A. J. 2007. Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, 1(2), pp. 112–133.

Jonkers, H., Proper, E., & Turner, M. 2009. TOGAF TM and ArchiMate ® : A Future Together. In The Open Group. Available at http://www.itilbookshop.org/Player/eKnowledge/togaf_and_archimate_a_future_together.pd.

Kaisler, S. & Armour, F. 2017. 15 Years of Enterprise Architecting at HICSS: Revisiting the Critical Problems In *Proceedings of the 50th Hawaii International Conference on System Sciences, 2017*, pp.. 4807–4816.

Kang, D., Lee, J., Choi, S., & Kim, K. 2010. An ontology-based Enterprise Architecture. Expert *Systems with Applications*, 37(2), pp. 1456–1464. https://doi.org/10.1016/j.eswa.2009.06.073

Kotusev, S. 2016. The History of Enterprise architecture: An Evidence-Based Review. *Journal of Enterprise architecture*, 12,(1), pp.. 29–37.

Kumari, N. 2012. A Study of the Recruitment and Selection process: SMC Global. Industrial *Engineering Letters,* 2(1), pp. 34–43. Available at www.iiste.org

Lankhorst, M. M., Proper, H. A., & Jonkers, H. (2009). The architecture of the ArchiMate language. In *Enterprise, business-process and information systems modeling* (pp. 367-380). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-01862-6_30

Legris, P., Ingham, J. & Colletrette, P. 1988. Cultural Reflections on American Linguists from Whitney to Sapir, *Journal of American Studies*, 22(2), pp. 185–212.

Merriam-webster.com. n.d. *Definition of framework*. [online] Available at https: / / www.merriam-webster.com / dictionary / framework [Accessed 22 Feb. 2019].

Merriam-webster.com. n.d. *Definition of methodology*. [online] Available at https: / / www.merriam-webster.com / dictionary / methodology [Cited 22 Feb. 2019].

Merriam-webster.com. n.d. *Definition of skillset*. [online] Available at https: / / www.merriam-webster.com / dictionary / skill%20set [Cited 22 Feb. 2019].

Morgan, D. L. 2014. Pragmatism as a Paradigm for Social Research, *Qualitative Inquiry*, 20(8), pp. 1045–1053.

Oates, B. 2006. *Researching information systems and computing*. Los Angeles: Sage, p.245-280.

Okhrimenko, A. 2017. Comparing Enterprise Architecture Frameworks – A Case Study at the Estonian Rescue Board. *UNIVERSITY OF TARTU.*

Opengroup.org. 2017. *ArchiMate® 3.0.1 Specification*. [online] Available at http: / / pubs.opengroup.org / architecture / archimate3-doc / chap03.html [Cited 27 May 2019].

Opengroup.org. 2018. *Togaf® Standard, Version 9.2*. [online] Available at https: / / publications.opengroup.org / c182 [Cited 28 Feb. 2019].

Osvalds, G. 2001. Definition of Enterprise Architecture-centric Models for the Systems Engineer. INCOSE *International Symposium*, 11(1), pp. 93–99. https://doi.org/10.1002/j.2334-5837.2001.tb02278.x

Ovidiu, N. 2003. An analysis of the Zachman framework for enterprise architecture from the GERAM perspective. *IFAC Annual Reviews in Control*, *27*(2), pp. 163–183.

Rajabi, Z., Minaei, B., & Ali Seyyedi, M. 2013. Enterprise architecture development based on enterprise ontology. *Journal of Theoretical and Applied Electronic Commerce Research*, 8(2), pp. 85–95. https://doi.org/10.4067/S0718-18762013000200007

Reynolds, M. & Holwell, S. 2010. *Systems approaches to managing change: A practical guide*. Springer London, pp. 191 -194

Riwanto, R. E., Mulia, U. B., Andry, J., & Mulia, U. B. (2019). Designing Enterprise Architecture Enable of Business Strategy and IS / IT Alignment in Manufacturing using TOGAF ADM Framework. *International Journal of Information Technology and Business*, 1(2), pp. 1–7. http://ejournal.uksw.edu/ijiteb

Robles, M. M., 2012. Executive Perceptions of the Top 10 Soft Skills Needed in Today's Workplace. *Business Communication Quarterly*, 75, pp. 453–465.

Schöenherr, M., 2009. Towards a common terminology in the discipline of enterprise architecture. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics),* pp. 400–413.

Sessions, R. 2007. A Comparison of the Top Four Enterprise-Architecture Methodologies. [Online]. Available at http: / / www3.cis.gsu.edu / dtruex / courses / CIS8090 / 2013Articles / A%20Comparison%20of%20the%20Top%20Four%20Enterprise-Architecture%20Methodologies.html [Cited 28 Feb. 2019].

Sfia-online.org. 2019. *Skills at a glance — SFIA*. [online] Available at https: / / www.sfia-online.org / en / framework / sfia-7 / skills-home [Cited 13 May 2019].

Sowa, J. F., & Zachman, J. A. 2010. Extending and formalizing the framework for information systems architecture. *IBM Systems Journal*, 31(3), pp. 590–616. https: / / doi.org / 10.1147 / sj.313.0590

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, pp. 38–47.

Teddlie, C. & Tashakkori, A. 2009. *Foundations of mixed methods research*. Los Angeles: SAGE, p. 93

The DoDAF Architecture Framework Version 2.02 (2011). *The DoDAF Architecture Framework Version 2.02.* [Online]. Available at https: / / dodcio.defense.gov / Portals / 0 / Documents / DODAF / DoDAF_v2-02_web.pdf [Cited 3 June 2019]

The Open Group (2009). TOGAF Version 9. ISBN: 978-90-8753-230-7. Avaiable at https://www.opengroup.org/togaf [Cited 15 November 2021)

Weber, R. 2004. Positivism Versus Interpretivism, *MIS Quarterly*, 28(1), pp. 3–12.

Yvonne Feilzer, M. 2010, Doing Mixed Methods Research Pragmatically: Implications for the Rediscovery of Pragmatism as a Research Paradigm, *Journal of Mixed Methods Research,* 4(1), pp. 6–16.

Zachman, J. 1997. Enterprise architecture: The Issue of the Century. *Database Programming and Design*, 10*(*3), pp. 44–53.

Zachman, J. 2008. *About the Zachman Framework*. [online] Available from https: / / www.zachman.com / about-the-zachman-framework [Cited 23 May 2019].

Zachman, J. A. 1999. A Framework for information systems architecture. *IBM Systems Journal*, 38(2), pp. 454–470. https: / / doi.org / 10.1147 / sj.382.0454

Zachman, J. n.d. *The Framework for Enterprise architecture: Background, Description, and Utility by John A. Zachman*. [Online] Zachman. Available at https: / / www.zachman.com / resources / ea-articles-reference / 327-the-framework-for-enterprise-architecture-background-description-and-utility-by-john-a-zachman [Cited 22 Feb. 2019].

Appendix

Appendix A - Standardized Naming Conventions

TOGAF Category	TOGAF Skill	Link
Business Skills and Methods		
	Business Case	Business analysis
	Business Scenarios	Business analysis
	Organisation	Organisational capability development, Organisation design and implementation
	Business Process	Business process improvement, Business process testing
	Strategic Planning	Strategic planning
	Budget Management	Financial management, Analytics
	Visioning	Information systems coordination
	Business Metrics	Business analysis
	Business Culture	
	Legacy Investments	
	Business Functions	Business analysis, Capacity management
Enterprise Architecture Skills		
	Business Modelling	Business modelling
	Business Process Design	Business modelling, Business process testing, Business process improvement
	Role Design	Information governance
	Organisation Design	Organisation design and implementation
	Data Design	Data modelling and design, Information assurance
	Application Design	Software design
	Systems Integration	Systems integration and build
	IT Industry Standards	Enterprise IT governance
	Services Design	Availability management, Service level management
	Architecture Principles Design	Enterprise and business architecture
	Architecture views and viewpoints Design	Enterprise and business architecture
	Building Block Design	Enterprise and business architecture, Solution architecture
	Solutions Modelling	Solution architecture
	Benefits Analysis	Benefits management

TOGAF Category	TOGAF Skill	Link
	Business-inter Working	Configuration management
	Systems Behaviour	Configuration management
	Project Management	Project management
Program or Project Management Skills		
	Program Management	Programme management
	Project Management	Project management
	Managing Business Change	Change implementation planning and management
	Change Management	Change management
	Value Management	Portfolio management
IT General Knowledge Skills		
	It Application Development methodologies and tools	Methods and tools
	Programming Languages	Programming/software development
	Brokering Applications	Porting/software configuration
	Information consumer Applications	Capacity management, Information assurance
	Information Provider Applications	Capacity management, Information assurance
	Storage Management	Storage management, Information assurance
	Networks	Network planning, Network design, Network support
	Web-Based Services	Network design
	IT Infrastructure	IT infrastructure
	Asset Management	Asset management
	Service Level Agreements	Service level management, Service acceptance
	Systems	System software, Systems design
	COTS	Capacity management
	Enterprise Continuums	Organisation design and implementation
	Migration Planning	Data management, Porting/software configuration, Release, and deployment
	Management Utilities	Continuity management
	Infrastructure	IT infrastructure
Technical IT Skills		
	Software Engineering	Software design
	Security	Information security, Security administration, Penetration testing
	Systems & Network Management	IT management, Systems development management
	Transaction Processing	Information assurance

TOGAF Category	TOGAF Skill	Link
	Location & Directory	Systems installation/decommissioning
	User Interface	Data visualisation
	international Operations	Information content publishing
	Data Interchange	Information content authoring
	Data Management	Data management
	Graphics and Images	Animation development
	Operating Systems Services	Service level management
	Network Services	Network planning, Network design, Network support
	Communications Infrastructure	IT infrastructure

Appendix B: Skill Cross-Comparison

SFIA Category	SFIA sub-category	SFIA Skill	Zachman	FEAF	Gartner	TOGAF	TOTAL
Strategy and architecture							
	Information strategy						
		Enterprise IT governance	1	1	1	1	Enterprise IT governance : 4
		Strategic planning	1	1	1	1	Strategic planning : 4
		Information governance	1	1	1	1	Information governance : 4
		Information systems coordination	1	1	1	1	Information systems coordination : 4
		Information security	1	1	1	1	Information security : 4
		Information assurance	1	1	1	1	Information assurance : 4
		Analytics	1	1	1	1	Analytics : 4
		Data visualisation	1	1	1	1	Data visualisation : 4
		Information content publishing	1	1	1	1	Information content publishing : 4
	Advice and guidance						: 0
		Consultancy					Consultancy : 0
		Specialist advice					Specialist advice : 0
	Business strategy and planning						: 0
		Demand management	1	1	1		Demand management : 3
		IT management	1	1	1	1	IT management : 4
		Financial management	1	1	1	1	Financial management : 4
		Innovation	1	1	1		Innovation : 3
		Research	1	1	1		Research : 3
		Business process improvement	1	1	1	1	Business process improvement : 4
		Knowledge management	1	1	1		Knowledge management : 3
		Enterprise and business architecture	1	1	1	1	Enterprise and business architecture : 4
		Business risk management	1	1	1		Business risk management : 3
		Sustainability	1	1	1		Sustainability : 3
	Technical strategy and planning						: 0
		Emerging technology monitoring	1	1			Emerging technology monitoring : 2

SFIA Category	SFIA sub-category	SFIA Skill	Zachman	FEAF	Gartner	TOGAF	TOTAL
		Continuity management	1	1		1	Continuity management : 3
		Network planning	1	1		1	Network planning : 3
		Solution architecture	1	1		1	Solution architecture : 3
		Data management	1	1		1	Data management : 3
		Methods and tools	1	1		1	Methods and tools : 3
Change and transformation							: 0
	Business change implementation						: 0
		Portfolio management		1	1	1	Portfolio management : 3
		Programme management		1	1	1	Programme management : 3
		Project management		1	1	1	Project management : 3
		Portfolio, programme and project support		1	1		Portfolio, programme and project support : 2
	Business change management						: 0
		Business analysis		1	1	1	Business analysis : 3
		Business modelling		1	1	1	Business modelling : 3
		Requirements definition and management		1	1		Requirements definition and management : 2
		Organisational capability development		1	1	1	Organisational capability development : 3
		Organisation design and implementation		1	1	1	Organisation design and implementation : 3
		Change implementation planning and management		1	1	1	Change implementation planning and management : 3
		Business process testing		1	1	1	Business process testing : 3
		Benefits management		1	1	1	Benefits management : 3
Development and implementation							: 0
	Systems development						: 0
		Systems development management	1	1		1	Systems development management : 3
		Systems design D	1	1		1	Systems design D : 3

SFIA Category	SFIA sub-category	SFIA Skill	Zachman	FEAF	Gartner	TOGAF	TOTAL
		Software design	1	1		1	Software design : 3
		Programming/software development	1	1		1	Programming/software development : 3
		Real-time/embedded systems development	1	1			Real-time/embedded systems development : 2
		Animation development	1	1		1	Animation development : 3
		Data modelling and design	1	1		1	Data modelling and design : 3
		Database design	1	1			Database design : 2
		Network design	1	1		1	Network design : 3
		Testing	1	1			Testing : 2
		Safety engineering	1	1			Safety engineering : 2
		Information content authoring	1	1		1	Information content authoring : 3
	User experience						: 0
		User research					User research : 0
		User experience analysis					User experience analysis : 0
		User experience design					User experience design : 0
		User experience evaluation					User experience evaluation : 0
	Installation and integration						: 0
		Systems integration and build				1	Systems integration and build : 1
		Porting/software configuration				1	Porting/software configuration : 1
		Hardware design					Hardware design : 0
		Systems installation/decommissioning				1	Systems installation/decommissioning : 1
Delivery and operation							: 0
	Service design						: 0
		Availability management				1	Availability management : 1
		Service level management				1	Service level management : 1
	Service transition						: 0
		Service acceptance				1	Service acceptance : 1
		Configuration management				1	Configuration management : 1
		Asset management				1	Asset management : 1

SFIA Category	SFIA sub-category	SFIA Skill	Zachman	FEAF	Gartner	TOGAF	TOTAL
		Change management				1	Change management : 1
		Release and deployment				1	Release and deployment : 1
	Service operation						: 0
		System software				1	System software : 1
		Capacity management				1	Capacity management : 1
		Security administration				1	Security administration : 1
		Penetration testing				1	Penetration testing : 1
		Radio frequency engineering					Radio frequency engineering : 0
		Application support					Application support : 0
		IT infrastructure				1	IT infrastructure : 1
		Database administration					Database administration : 0
		Storage management				1	Storage management : 1
		Network support				1	Network support : 1
		Problem management					Problem management : 0
		Incident management					Incident management : 0
		Facilities management					Facilities management : 0
Skills and quality							: 0
	Skill management						: 0
		Learning and development management					Learning and development management : 0
		Competency assessment					Competency assessment : 0
		Learning design and development					Learning design and development : 0
		Learning delivery					Learning delivery : 0
		Teaching and subject formation					Teaching and subject formation : 0
	People management						: 0
		Performance management					Performance management : 0
		Resourcing					Resourcing : 0
		Professional development					Professional development : 0
	Quality and conformance						: 0
		Quality management					Quality management : 0
		Quality assurance					Quality assurance : 0

SFIA Category	SFIA sub-category	SFIA Skill	Zachman	FEAF	Gartner	TOGAF	TOTAL
		Measurement					Measurement : 0
		Conformance review					Conformance review : 0
		Safety assessment					Safety assessment : 0
		Digital forensics					Digital forensics : 0
Relationships and engagement							: 0
	Stakeholder management						: 0
		Sourcing					Sourcing : 0
		Supplier management					Supplier management : 0
		Contract management					Contract management : 0
		Relationship management					Relationship management : 0
		Customer service support					Customer service support : 0
	Sales and marketing						: 0
		Marketing					Marketing : 0
		Selling					Selling : 0
		Sales support					Sales support : 0
		Product management					Product management : 0

Appendix C: Skillset 1st Iteration

All skills

Rank	Skill	Rank	Skill
1	Business Strategic Planning	2	Analytics
1	IT Strategic Planning	2	Systems design
1	Information security	2	Systems integration and build
1	Demand management	2	Data modelling and design
1	Information assurance	2	Configuration management
1	Innovation	3	Information systems coordination
1	Research	3	Benefits management
1	Business risk management	3	Project management
1	Business analysis	3	Programme management
1	Business modelling	3	Business process testing
1	Organisational capability development	3	Financial management
1	Business Governance	3	Information content publishing
1	Change implementation planning and management	3	Data visualisation
1	Emerging Business Monitoring	3	Release and deployment
1	Portfolio management	3	Capacity management
1	Strategic Marketing	3	Network planning
1	Product and Service acceptance	4	Information content authoring
1	Process Engineering	4	Security administration
1	Enterprise and business architecture	4	Sustainability
1	Systems Thinking	4	Portfolio, programme and project support
1	Information Modeling	4	Safety engineering
1	Solution architecture	4	Porting/software configuration
1	Emerging technology monitoring	4	Systems development management
1	Component Based Design	4	Asset management
1	Technology Modeling	4	Systems Testing
1	Lifecycle Management	4	Programming/software development
1	IT infrastructure	4	Software design
2	Continuity management	4	Animation development
2	Requirements definition and management	4	Change management
2	Enterprise IT governance	4	Systems installation/decommissioning
2	Information governance	4	Methods and tools
2	Business process improvement	4	Network design
2	IT management	4	Real-time/embedded systems development
2	Service level management	4	Storage management
2	Knowledge management	4	Network support
2	Organisation design and implementation	4	System software
2	Data management	4	Penetration testing
2	Availability management		

Appendix D: ArchiMate Layer Classification

Business Layer	Application and Data Layer	Technology Layer
Business Strategic Planning	Systems Thinking	Emerging technology monitoring
IT Strategic Planning	Information Modeling	Component Based Design
Information security	Solution architecture	Technology Modeling
Demand management	Data management	Lifecycle Management
Information assurance	Availability management	IT infrastructure
Innovation	Analytics	Configuration management
Research	Systems design	Network planning
Business risk management	Systems integration and build	Methods and tools
Business analysis	Data modelling and design	Network design
Business modelling	Data visualisation	Real-time/embedded systems development
Organisational capability development	Release and deployment	Storage management
Business Governance	Capacity management	Network support
Change implementation planning and management	Safety engineering	System software
Emerging Business Monitoring	Porting/software configuration	Penetration testing
Portfolio management	Systems development management	
Strategic Marketing	Asset management	
Product and Service acceptance	Systems Testing	
Process Engineering	Programming/software development	
Enterprise and business architecture	Software design	
Continuity management	Animation development	
Requirements definition and management	Change management	
Enterprise IT governance	Systems installation/decommissioning	
Information governance		
Business process improvement		
IT management		
Service level management		
Knowledge management		
Organisation design and implementation		
Information systems coordination		
Benefits management		
Project management		
Programme management		
Business process testing		
Financial management		
Information content publishing		
Information content authoring		
Security administration		
Sustainability		
Portfolio, programme and project support		

Appendix E: Change list

ArchiMate Layer	Skill	Change
Business Layer	Enterprise IT governance	Enterprise IT governance Changed To Rank 2
Business Layer	Strategic planning	Strategic planning was split into Business Strategic Planning and IT Strategic Planning
Business Layer	IT management	IT management Changed To Rank 2
Business Layer	Financial management	Financial management Changed To Rank 3
Business Layer	Business process improvement	Business process improvement Changed To Rank 2
Business Layer	Solution architecture	Solution architecture Changed To Rank 1 Application/Data Layer
Business Layer	Systems development management	Systems development management Changed To Rank 4 Application/Data Layer
Business Layer	Demand management	Demand management Changed To Rank 1
Business Layer	Innovation	Innovation Changed To Rank 1
Business Layer	Research	Research Changed To Rank 1
Business Layer	Business risk management	Business risk management Changed To Rank 1
Business Layer	Sustainability	Sustainability Changed To Rank 4
Business Layer	Business analysis	Business analysis Changed To Rank 1
Business Layer	Business modelling	Business modelling Changed To Rank 1
Business Layer	Organisational capability development	Organisational capability development Changed To Rank 1
Business Layer	Change implementation planning and management	Change implementation planning and management Changed To Rank 1
Business Layer	Business process testing	Business process testing Changed To Rank3
Business Layer	Benefits management	Benefits management Changed To Rank 3
Business Layer	Portfolio management	Portfolio management Changed To Rank 1
Business Layer	Programme management	Programme management Changed To Rank 3
Business Layer	Project management	Project management Changed To Rank 3
Business Layer	Requirements definition and management	Requirements definition and management Changed To Rank 2
Business Layer	Portfolio, programme and project support	Portfolio, programme and project support Changed To Rank 4
Business Layer	Service acceptance	Service acceptance Changed To Product and service acceptance Rank 1
Business Layer	Asset management	Asset management Changed To Rank 4 Application/Data Layer
Business Layer	Change management	Change management Changed To Rank 4 Application/Data Layer
Business Layer	Release and deployment	Release and deployment Changed To Rank 3 Application/Data Layer
Business Layer	Capacity management	Capacity management Changed To Rank 3 Application/Data Layer
Business Layer	Availability management	Availability management Changed To Rank 2 Application/Data Layer
Application/Data Layer	Information systems coordination	Information systems coordination Changed to Rank 3 Business Layer
Application/Data Layer	Information security	Information security Changed to Business Layer
Application/Data Layer	Information assurance	Information assurance Changed to Business Layer
Application/Data Layer	Analytics	Analytics Changed to Rank 2
Application/Data Layer	Data visualisation	Data visualisation Changed to Rank 3
Application/Data Layer	Information content publishing	Information content publishing Changed to Rank 3 Business Layer
Application/Data Layer	Information governance	Information governance Changed to Rank 2 Business Layer

ArchiMate Layer	Skill	Change
Application/Data Layer	Software design	Software design Changed to Rank 4
Application/Data Layer	Programming/software development	Programming/software development Changed to Rank 4
Application/Data Layer	Animation development	Animation development Changed to Rank 4
Application/Data Layer	Information content authoring	Information content authoring Changed to Rank 4 Business Layer
Application/Data Layer	Database design	Database design was removed
Application/Data Layer	Testing	Testing Changed to Rank 4 Systems Testing
Application/Data Layer	System software	System software Changed to Rank 4 Technology Layer
Application/Data Layer	Security administration	Security administration Changed to Rank 4 Business Layer
Application/Data Layer	Penetration testing	Penetration testing Changed to Rank 4 Technology Layer
Technology Layer	Network planning	Network planning Changed to Rank 3
Technology Layer	Methods and tools	Methods and tools Changed to Rank 4
Technology Layer	Systems design	Systems design Changed to Rank 2 Application/Data Layer
Technology Layer	Network design	Network design Changed to Rank 4
Technology Layer	Emerging technology monitoring	Emerging technology monitoring Changed to Rank 1
Technology Layer	Real-time/embedded systems development	Real-time/embedded systems development Changed to Rank 4
Technology Layer	Safety engineering	Safety engineering Changed to Rank 4 Application/Data Layer
Technology Layer	Configuration management	Configuration management Changed to Rank 2
Technology Layer	IT infrastructure	IT infrastructure Changed to Rank 1
Technology Layer	Service level management	Service level management Changed to Rank 2 Business Layer
Technology Layer	Systems integration and build	Systems integration and build Changed to Rank 2 Application/Data Layer
Technology Layer	Porting/software configuration	Porting/software configuration Changed to Rank 4 Application/Data Layer
Technology Layer	Systems installation/decommissioning	Systems installation/decommissioning Changed to Rank 4 Application/Data Layer
New Skill	Business Governance	Added to Business Layer rank 1
New Skill	Emerging business monitoring	Added to Business Layer rank 1
New Skill	Strategic marketing	Added to Business Layer rank 1
New Skill	Process engineering	Added to Business Layer rank 1
New Skill	Systems Thinking	Added to Application/Data Layer rank 1
New Skill	Information modeling	Added to Application/Data Layer rank 1
New Skill	Component based design	Added to Technology Layer rank 1
New Skill	Technology modeling	Added to Technology Layer rank 1
New Skill	Lifecycle management	Added to Technology Layer rank 1

Appendix F: Skillset 2nd Iteration

Change List

ArchiMate Layer	Skill	Change
Business Layer	Demand Management	Demand Management Changed to Rank 2
Business Layer	Business Risk Management	Business Risk Management Changed to Rank 1
Business Layer	Strategic Marketing	Strategic Marketing Changed to Rank 4
Business Layer	Product and Service Acceptance	Product and Service Acceptance Changed to Rank 2
Business Layer	Process Engineering	Process Engineering Changed to Application/Data Layer
Business Layer	Requirements Definition and Management	Requirements Definition and Management Changed to Rank 1
Business Layer	Enterprise IT Governance	Enterprise IT Governance Changed to Rank 1
Business Layer	Business Process Improvement	Business process Improvement Changed to Rank 3
Business Layer	Organisation Design and Implementation	Organisation Design and Implementation Changed to Rank 1
Business Layer	Programme Management	Programme Management Changed to Rank 4
Business Layer	Financial Management	Financial Management Changed to Rank 2
Business Layer	Information Content Publishing	Information Content Publishing Changed to Application/Data Layer
Business Layer	Information Content Authoring	Information Content Authoring Changed to Application/Data Layer
Business Layer	Security Administration	Security Administration Changed to Rank 3
Business Layer	Sustainability	Sustainability Changed to Rank 3
Application/Data Layer	Systems Thinking	Systems Thinking Changed to Business Layer
Application/Data Layer	Information Modeling	Information Modeling Changed to Business Layer
Application/Data Layer	Data Management	Data Management Changed to Rank 1
Application/Data Layer	Systems Desgin	Systems Design Changed to Rank 1
Application/Data Layer	Data Modelling and Design	Data Modelling and Design Changed to Rank 1

ArchiMate Layer	Skill	Change
Application/Data Layer	Release and Deployment	Release and Deployment Changed to Technology Layer
Application/Data Layer	Capacity Management	Capacity Management Changed to Technology Layer
Application/Data Layer	Systems Development Management	Systems Development Management Changed to Rank 3
Application/Data Layer	Animation Development	Animation Development Changed to Removed
Application/Data Layer	Change Management	Change Management Changed to Rank 3
Application/Data Layer	Systems Installation/Decommissioning	Systems Installation/Decommissioning Changed to Rank 2 Technology Layer
Technology Layer	IT Infrastructure	IT Infrastructure Changed to Rank 2
Technology Layer	System Software	System Software Changed to Application/Data Layer